LIFE STORIES

OF

AUSTRALIAN INSECTS

By

MABEL N. BREWSTER, AGNES A. BREWSTER

AND

NAOMI CROUCH

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LIFE STORIES OF AUSTRALIAN INSECTS

Carter's Printing Works, 377 Sussex Street, Sydney.

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— OF —

Australian Insects

— BY —

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SYDNEY:

DYMOCK'S BOOK ARCADE

1920

Introduction.

Of the natural history books available to us, most of them dealing with insect life refer mainly to European or American species. It is therefore a pleasure to handle an Australian publication such as this, describing and figuring Australian types, and, furthermore, written by Australians.

Since Froggatt's "Australian Insects," now out of print, there has been need for a small handbook on Australian insects and their habits, and the following book presents an embracive, and yet not too technical, treatment of this subject which will be invaluable to school teachers and students interested in Entomology.

The three authors, some years ago, were students in my course in Entomology at the Sydney Technical College, and have since continued the study of insect life with unswerving interest. Miss Mabel Brewster has published several papers in the "Australian Naturalist" on the Hymenoptera. Miss Crouch is lecturer in Nature Study at the Teachers' Training College, and Miss A. Brewster, well known as joint author with Miss Leplastrier of an Australian Botany, has been Science Teacher at the Girls' High School, Sydney, for many years.

Numerous illustrations, many of which are original, have been provided. The external and internal structure of various insect types are dealt

with, which, besides its interest, is essential to the proper understanding of the relationship among the vast hordes of insect species extant, and to their systematic grouping into orders, sub-orders, and families, which are defined by the authors throughout the book. Then the life histories of many species have been described and figured, which revealing the development, metamorphoses, and the behaviour of insects, proves of perennial interest to students.

Finally, in recalling the bionomics of leaf and fruit-eating species, sap-sucking and wood-boring insects, and the blood-sucking forms which affect stock or man, the economic significance of insect life becomes apparent. Apart from their interest, the lives of both useful and injurious species will take on a new importance in the minds of readers. The adequate study of insects which occasion such losses in our crops, orchards and gardens, which affect stock, destroy stored products, or are concerned in carrying disease, presents a huge and varied field for research. This is the province of Economic Entomology, and it is augmented by the research and experiments necessary to arrive at effective and yet economical methods of control, whether by spraying, fumigation, modifying farm practice, by the artificial encouragement of natural parasitism, or whatever means may suggest itself and prove effectual in preventing or controlling a pest. Communities are now growing to realise the increased production and immediate monetary saving which may result from such investigations by

entomologists, and that its health may depend on adequate control of flies and other insects responsible for the transmission of malaria, yellow fever, typhoid, filariasis, trench fever, and other diseases. Some understanding of insects, and their role in our lives, therefore concerns both those on the land and city people, and the subject could with advantage be more seriously studied in our schools.

W. B. GURNEY.

Preface.

We have written this book because of the lack of an elementary text-book with sufficient detailed work and classifications of insects to enable students of Entomology to prepare for the study of higher text-books and reference books.

This book should fill in a gap between Gillies' "Insect Studies," Gladys Froggatt's "World of Little Lives," and the more advanced text-books.

We have given some of the results of years of observation, the working out of life histories, all of which included field or laboratory work or both. The field of Entomology is so vast that such observations are necessarily limited, but we have quoted, where possible, the results of other workers. Our great hope is that this little book may encourage new workers in the fields not yet explored.

We wish to thank Mr. W. B. Gurney, F.E.S., Assistant Government Entomologist, for helpful suggestions when reading through the manuscript; also Mr. G. A. Waterhouse, B.Sc., B.E., F.E.S., for reading through the Order Lepidoptera, especially of Rhopalocera, and for the general reading through of the manuscript. We are indebted to Dr. R. J. Tillyard for helpful criticism and advice as regards the Order Neuroptera and allied "Lace-wing" Orders; also for the table of classification of such, as

seen in the text; to Mr. W. Froggatt, F.E.S., Government Entomologist, for literature on various sections of Entomological Research.

Students will find that the following works will be invaluable for reference: Froggatt's "Australian Insects," and various entomological papers published periodically in the Agricultural Gazette of New South Wales. "The Biology of Dragon Flies," by Dr. R. J. Tillyard. Various papers published in the "Proceedings of the Linnean Society of New South Wales," "Butterflies of Australia," by Waterhouse and Lyell.

The drawing are made from originals, except where acknowledgment is made.

M.V.B.

M.N.B.

N.C.

List of Illustrations.

Plate.		Page.
1.	Insects	xii.
2.	Insects	5
3.	Silverfish and Parts of Grasshoppers	14
4.	Cockroaches and Grasshoppers	23
5.	Mantids	30
6.	Phasmids	34
7.	Grasshoppers and Earwigs	40
8.	White Ants	46
9.	Mole Crickets	60
10.	Dragon Fly and Nymph	66
11.	Dragon Flies and May Flies	69
12.	Lace Wings	80
13.	Ant Lions and Caddis Flies	88
14.	Hymenoptera	102
15.	Chalcids	113
16.	Parasitic Wasps	120
17.	Life History of Ichneumon Wasp	123
18.	Ants	132
19.	Nest of Ants	140
20.	Ants	142
21.	Wasps	174
22.	Wasps	182
23.	Wasps	188
24.	Life History of Paper Wasp	196
25.	Bee	214
26.	Parts of Bee	221
27.	Native Honey Bee	223
28.	Life History of Beetle	229
29.	Beetles	234
30.	Beetles	243

Plate		Page
31.	Beetles	248
32.	Longicorn and Chrysomelid Beetles	256
33.	Water Beetles	263
34.	Ladybird Beetles and Weevils	256
35.	Butterflies	277
36.	Moths	298
37.	Case Moths	302
38.	Emperor Gum Moth and Proboscis of Moth	309
39.	Moths	322
40.	Flies	328
41	Mosquitoes	335
42.	Flies	342
43.	Flies	349
44	Blow Fly	354
45.	Bot Fly	367
46.	Fruit Fly	371
47.	The Flea	374
48.	Cicada, Membracid and Froghopper	378
49.	Aphides and Lerps	387
50	Scale Insects and Mealy Bugs	391
51	Galls and Fulgorids	397
52.	Plant Bugs	399
52.	Water Bugs	404

Fig 1 An Insect - a Head b Thorax
c Abdomen d Antenna

Fig 2 Biting Mouth of House Cockroach
a Mandible b First Maxilla
c Labium

Fig 3 Head of Cicada
a Ocelli b Eye

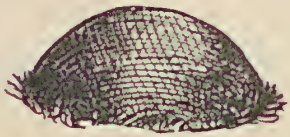


Fig 4 Compound Eye

Fig 5 Facets of Compound Eye

AN INSECT.

Definition.—The term "insect" is popularly and wrongly given to almost any small animal such as spiders, scorpions, centipedes, etc. Briefly, an insect is an animal whose body is divided into 3 parts (1) head, (2) thorax, (3) abdomen, and which has 3 pairs of legs attached to the thorax. (Plate 1, Fig. 1).

Classification.—The Animal Kingdom is divided into several great divisions called **Sub-Kingdoms** or **phyla.** The Sub-Kingdom or phylum to which insects belong is the **Arthropoda** or animals with jointed appendages. This includes forms with a body having ring-like parts. They differ from the Phylum Annulata (worms) in having distinct limb segments.

The Phylum **Arthropoda** is divided into 5 classes:

I. **Crustacea:** Crabs, lobsters, shrimps.
II. **Arachnida:** Spiders, scorpions, ticks, mites.
III. **Insecta:** Insects such as flies, bees, crickets, beetles, etc.
IV. **Myriapoda:** Centipedes and millipedes.
V. **Onychophora:** Peripatus.

We may now state (with more detail) that an insect is a small animal, having a body made up of a number of ringed parts, slightly horny, being grouped in three distinct regions, known as (a) the

head, (b) the **thorax,** (c) the **abdomen.** To the thorax are attached the three pairs of legs and the two pairs of wings. (Plate 1. Fig. 1.) (Note that some insects have but one pair of wings and others are wingless.) The abdomen may carry the sting, and in the case of females an ovipositor (egg placer), or a saw (example, sawflies).

External Structure.—The outer skin of an insect is somewhat hardened by the deposition in its cells of a horny substance called **chitin.** This hardness of the integument affords the insect a protection as there is no internal skeletal structure.

The Head.—This is usually more or less rounded and made of a number of segments welded together. To the head are attached the following: (1) The **Antennæ** or feelers (Plate 1, Fig. 1. d). These are jointed structures situated on the front of the head and usually between the eyes. In some insects they are very short, *ex.*: cicada. Their length varies, however; some tree grasshoppers have antennæ from 4 to 6 inches long. The antennæ may be organs of feeling, smelling, or even hearing. (2) **Eyes:** Most insects have one pair of compound eyes (Plate 1, Fig 4) which are immovable and each eye is made up of a number of small structures or eyes called facets (Plate 1. Fig. 5). Each of these facets is a centre of vision. The number of facets varies from a few in some insects, to several thousands in others. In addition to the compound eyes are simple eyes, or **Ocelli** (Plate 1, Fig. 3a), varying in number from 1 to 5, though 3 is the usual number; these are

placed in most cases between the large eyes. The function of these rudimentary eyes is thought to be limited to distinction of light from darkness. They are well seen on the head of the cicada as 3 tiny sparkling "gems" between the compound eyes. (Plate 1. Fig. 3a.) (3) **Mouth Parts:** The mouths of insects vary according to their methods of obtaining food and their habits. The more normal mouth of insects is the **biting mouth** (Plate 1, Fig. 2). It consists of an upper lip: the **labrum**; a pair of stout jaws, called **mandibles**, stand prominently below the labrum or upper lip: these are seizing, tearing and biting jaws. There is a pair of outer flexible chewing jaws called **first** or **outer maxillæ**; there are usually 2 teeth present on each maxilla, and a long five-jointed palpus (often called palp). There is an inner pair of maxillæ with three-jointed palpi; these jaws are usually fused to form a solid central and posterior basal lip called generally the **labium.** The palpi or palps are used as fingers to direct the food towards the mouth and to aid in holding food.

In the case of insects with purely sucking habits, the mouth is modified to form a sucking tube which consists of 2 long half tubes which, when placed together, form a sucking apparatus. (Plate 38. Figs. 5, 6, 7.) In other insects the piercing and sucking mouth is represented by a certain number of setæ or bristles (formed by a modification of the mouth parts) which are placed close together to form a canal (Plate 41, Fig. 1). The tips of the setæ pierce a leaf, or body of an insect, etc., and the moisture is drawn through the

tube formed by the closely adpressed setæ or stylets. There is a sheath present to enclose the stylets.

II. **The Thorax** is the 2nd division of the body: and is made up of three more or less distinct segments known respectively as (a) **prothorax,** (b) **mesothorax,** (c) **metathorax.** In some insects these are fused so that one can not distinguish the segments.

The prothorax carries the 1st pair of legs; the mesothorax the 1st pair of wings and the 2nd pair of legs; the metathorax, the 3rd pair of legs and the 2nd pair of wings.

The leg of an insect can be divided into 5 distinct parts (Plate 2, Fig. 1): (1) The coxa or hip; (2) the **trochanter** (usually very small); (3) the **femur,** or thigh (4) **tibia,** or shank; (5) **tarsus,** or foot, which has usually 5 joints, the last joint carrying claws and sometimes a pad also, called the **pulvillus.** (Plate 2. Fig 2 a, b.)

Wings.—Wings differ according to the different orders, but broadly speaking they are more or less triangular in shape and usually membranous, supported by thickened lines called **veins.** The arrangement of the veins varies also. Dipterous insects (flies, mosquitoes, etc.) and a few others have but 2 wings, the hind pair of wings being absent; in their place is a pair of knobbed processes called **halteres** or balancers. (Plate 42, Figs. 2, 8.) Some insects have no wings, as fleas and silverfish.

III. Abdomen.—This is the third and terminal division of the body, and is made up of ringed segments, sometimes 9 or 10 in number, but the

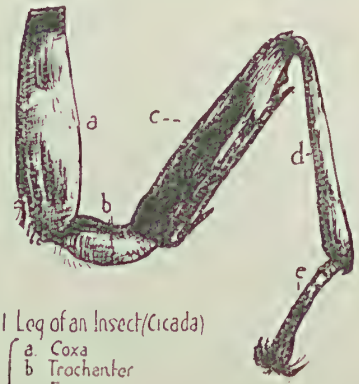


Fig. 1 Leg of an Insect (Cicada)
- a. Coxa
- b Trochanter
- c. Femur
- d. Tibia
- e Tarsus or Foot

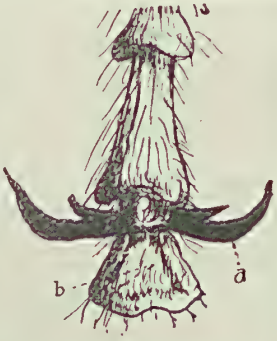


Fig 2 Lower Joint of Foot
- a Claw
- b Pad

Fig 3 Imperfect Metamorphosis (Froghopper)
- a. Larva
- b. Nymph
- c. Adult

Fig 4 Perfect Metamorphosis (Ant)
- a Larva
- b. Pupa
- c Adult.

INSECTS (all enlarged).

number varies in different insects. Usually the last two segments are hidden from view by the overlapping of the previous segment. The horny rings are joined by thinner membranes, and the body is flexible. The females have an ovipositor or egg-placer (Plate 3, Fig 8, a), made up of a varying number of plates or parts. More usually the ovipositor is concealed within the abdomen, but in many wasps is quite long and prominent. (Plate 14, Fig. 3). The ovipositor can be modified to form a sting or saw. (Plate 14, Figs. 4, 6, 7.)

Internal Structure of Insects.

Breathing.—An insect has no lungs, but the air is taken into the body through a number of minute pores called **stigmata** or **spiracles.** (Plate 36, Fig. 1, a) situated along each side of the abdomen and thorax. These are the external openings to the **tracheæ** or air tubes, of which there are two main branches running down each side of the body, and large cross tracheæ also in the abdomen and thorax, and from these, innumerable branches are given off so that air can be carried to every part of the body. The tubes are thickened by a spiral close-wound thread-like band, giving them a striated appearance.

Blood Vessels.—The blood system is very simple. There is a very elementary heart, which is divided usually into 8 chambers by a number of valves. This is prolonged into a main tube or vessel which carries the blood into a number of spaces in the

body cavity so that the blood is free and "bathes" the organs of the body.

Digestion.—The digestive system includes mouth cavity, salivary glands, and a crop for storage of food. (This in insects with a sucking mouth is termed a sucking stomach, and is modified to store liquids.) Then there is a digestive stomach with organs secreting digestive fluids, and also a large and small intestine. Between the crop and the stomach is sometimes a gizzard or small chamber armed with chitinous teeth which break up the food.

The Senses of Insects.

Feeling.—Insects have a nervous system and a rudimentary brain, hence can feel, but not to the same degree as higher animals. **Hearing.**—Although a knowledge of the sense is very limited, still it is known that certain insects have a definite hearing organ. The short horned grasshoppers have an auditory organ on the 1st segment of the abdomen. (Plate 3, Fig. 7a.): long-horned grasshoppers have one on the tibia of each front leg. (Plate 3, Fig. 6a.). Some writers think that sound can be detected through the medium of the antennæ. Some hairs on the antennæ of the mosquito have responded to vibrations of a tuning fork; the hum of the female is pitched so as to set these hairs in motion. Ants and bees are said to have small depressions on the antennæ which seem sensitive to sounds. Insects which have the power of making the most noise have the best developed organs of hearing; for example, grasshoppers,

crickets. As it is the male in most cases which makes the strongest sounds, it is supposed to be a call-note chiefly for the female. **Taste.—The** sense of taste is located in the roof of the mouth, but when the mouth is such as not to permit of this, the organs immediately around the mouth serve the purpose by means of minute depressions. Experiments prove that the sense of taste is more keenly developed in some insects than in others. **Smell.**—The antennæ are thought to act as organs of smell.

Development of an Insect.—Every insect is developed from an egg, which as a rule is deposited, but in a few cases is hatched within the body; in this case a living larva is the result; *ex.*: some species of flies.

The eggs vary in shape and size, and when examined with a lens some show beautiful carvings, knobs, etc. The color of eggs varies from cream, white, grey, green, brown, even to bright orange.

Eggs are found according to the feeding habits of the larvæ—on leaves, on bark, on or in soil, on rock, in cracks, etc. Sometimes they are enclosed in a capsule; *ex.*: the cockroach; in the case of the Praying Mantis they are enveloped in a tough, spongy case (Plate 7, Fig. 3). They are usually sticky when first laid, and so stick fast to the leaf, etc., on which they are placed. In many phasmids the eggs are seed-like and are dropped to the ground when the adults are on the plants.

The **Metamorphosis** of the insect means the changes which the insect undergoes from its hatch-

ing till it reaches the adult stage. There are two types of metamorphosis (1) **Perfect or Complete**; (2) **Imperfect or Incomplete.** (1) **Perfect Metamorphosis.** There are three stages: (a) larva; (b): pupa; (c): adult. (Plate 2, Fig. 4). When the larva hatches from the egg it is quite unlike its parents, and may assume one of three forms (a) a Caterpillar, (b) a Grub, (c) a Maggot.

Larvæ shed their skins or moult a number of times. The number of moults is five or six, but the larva of the dragon fly moults from ten to fifteen times. After each moult the larva has increased in size.

Types of Larvæ.—(a) A **Caterpillar** (Plate 35, Fig. 1) has a long cylindrical body made of a number of ringed segments. It has three pairs of horny legs, one pair on each of the first three segments of the body. Also there are usually four pairs of fleshy legs or prolegs. These are found further back and are necessary to support the long body of the caterpillar. On the last segment is a pair of anal claspers, and these are sometimes very powerful organs for clinging to twigs, etc.; *ex.*: the caterpillars of the Emperor Gum Moth, or Privet Hawk Moth. The larvæ of moths and butterflies are caterpillars. The moth larvæ, called "loopers," have only two pairs of prolegs, and some of the boring moth-larvæ have only rudimentary legs.

(b) A **Grub** (Plate 28, Fig. 3 a) is not unlike a caterpillar, but as a rule, it has no prolegs, but three pairs of horny legs in front. The grubs in some

species of saw-flies have many prolegs. Wood boring grubs of beetles are practically legless.

(c) A **Maggot** (Plate 2, Fig. 4 a) is a legless grub, and the most specialised maggot is that of the flies, such as house flies and blow flies.

Pupa (Plate 2, Fig. 4 b).—After a series of moults the larva pupates, *i.e.*, it changes from a larva to a pupa. The pupa never feeds and is usually quiescent, though some pupæ are very active, for example, the mosquito. The larva on pupating usually shrinks and is covered with a general enveloping membrane or pupal skin. This may be a covering like a sac or bag; *ex.*: butterflies; or may follow the outline of the appendages, head, etc., and both form what is termed a naked pupa: for example, some species of ants (Plate 2, Fig. 4 b), and beetles (Plate 28, Fig. 3 b). In other cases as before mentioned, there is a general enveloping skin enclosing the pupa, example, pupæ of butterflies and moths; in the moth, the pupa is further protected with a silken bag called a cocoon (Plate 39, Fig. 4), while in some cases moth-larvæ pupate in the ground. In many flies, the last larval skin is used as a kind of protecting skin, and is called a puparium, example, the house and blow flies (Plate 44, Fig. 3 and Fig. 8): it is seed-like in these species. The pupal case is usually split along the back and the **imago** or **perfect insect** emerges.

The larvæ which form cocoons, in most cases cut their way through the silk from one end; in the Cup Moth the pupating larva forms a lid and this is pushed off on emerging. This is the case also with some wasps (Plate 16, Fig. 4 a).

Thus there are three distinct stages in Complete or Abrupt Metamorphosis: (a) larva, (b) pupa, (c) Adult.

Incomplete Metamorphosis. (Plate 2, Fig. 3). In this case the larva hatches from the egg with a form very similar to the parents, only that all the organs and some parts are not fully grown or developed; also no wings are present. However, in the later phases of development wing pads appear: it is now called a **Nymph,** though some authors use the term "Nymph" for the whole larvæ stage: finally the wings and all the organs are properly developed and the insect is an adult; *ex.*: grasshoppers, crickets, etc.

Classification of Insects.

The great class Insecta is divided usually into 9 large **Orders,** but some writers subdivide some of these, making more orders. The orders are divided into **Families,** and in these families are included **Genera,** a kind of "surname," while Genera are again subdivided into species and the latter is a kind of "christian" name.

For example: The Hawk Moth *Protoparce Convolvuli* can thus be classified:—

(1) Class. **Insecta.**
(2) **Order: Lepidoptera.**
(3) **Family: Sphingidæ.**
(4) **Genus** *Protoparce.*
(5) **Species:** *Convolvuli.*

Orders and families can be divided again into

sub-orders, sub-families, etc., so that detailed classification can be extended.

Classification into orders is based largely on (1) the nature of the wings; (2) the character of the mouth parts; (3) mode of development.

ORDER—APTERA.

(Silver Fish and Spring-tails.)

"Aptera" means without wings, and this order includes Silverfish and Spring-tails. (Plate 3, Figs. 1 and 3.)

These are very primitive insects, and are quite destitute of wings during the whole length of their life. They have not even rudimentary wings.

They have three pairs of legs borne by the thoracic segments. The integument or outer covering is very weak and soft, and the body is covered with easily removed scales. They resemble the larvæ of some other insects, and adults can only be told by their sizes, and the full development of their parts, such as the number of joints of the antennæ. The ring-like segments of the body are very similar, the thoracic segments being broader and carry the legs, but in some groups there is little difference between the segments of the thorax and the abdomen.

The respiratory or breathing system is very simple, and, in some types, is very immature. The long tracheal trunk lines, which occur in most insects along the sides of the body, and from the lateral branches of which the spiracles open out, are absent in some of these insects.

The food of insects of the Order Aptera is de-

Fig. 1. Silver Fish (Lepisma.)
a. Cerci

Fig. 2. Body Scales of Silver Fish.
(highly Magnified)

Fig. 3. Springtail Lipura.

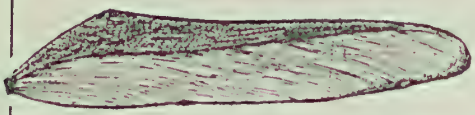


Fig 4. Cover Wing of Locust.

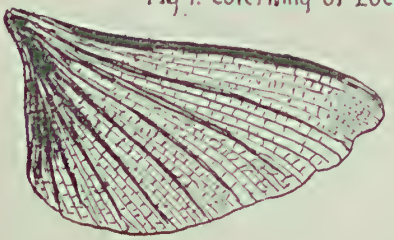


Fig 5. Flying Wing of Locust.

Fig 6. Front Leg of Longhorn.
(grasshopper)
a. "ear."

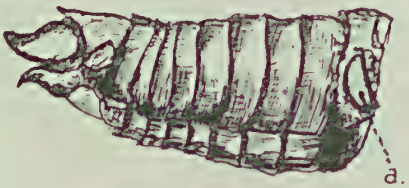


Fig 7. Abdomen of Locust
a. "Ear".

Fig 8. Nymph of Longhorn.
a. Ovipositor.

SILVER FISH AND PARTS OF GRASSHOPPERS.

composing vegetable and animal matter. The metamorphosis is imperfect, and most of these creatures cannot stand a dry atmosphere; they can bear heat and cold, but not dryness.

There are two Sub-Orders:—(1) **Thysanura** or Silver Fish group; (2) **Collembola** or Spring-tails.

———:o:———

(1) SUB-ORDER—THYSANURA.

Family—Lepismidæ.

These insects are about ¾in. to under 1 inch in length, and are covered with scales, giving the body a dull silvery metallic appearance.

The thoracic segments differ from those of the abdomen and also from one another; they are rounded at the edges; there are 10 segments of the abdomen; the tracheal system is well developed. The body tapers towards the end and there are five appendages. There are three long appendages easily distinguished with the naked eye; the middle one is twice as long as the two lateral cerci, as they are called. Between these there are two much shorter appendages (seen with a lens). All these five caudal (belonging to a tail) appendages are jointed with tufts of hair at each segment. Some of the hairs (when examined with the low power of microscope) are seen to stand out at an angle to the appendages, while the majority of them lie close to the sides.

The antennæ are long, and consist of a number of segments similar to the caudal appendages but smaller. The hair tufts are seen here too. Hair tufts occur at each segment of the body of the silver fish. When the scales are examined with the microscope, they are seen to be very beautiful,

resembling transparent rose petals, with a little notch at the base. (Plate 3, Fig. 2.) Some are linear, and some are rounded. The scales are modified hairs flattened out to form a soft covering over the surface.

Silver Fish have very free movement and can slip into cracks and disappear with great speed. The scales are smooth and give the surface a slippery feel which enables the insects to slip away when seized, especially as the scales can easily be rubbed off.

The genus *Lepisma* (Plate 3, Fig. 1) is the common silver fish. We kept one in captivity, and it moulted, for the skin was seen: on looking a little later the skin had disappeared—eaten by the silver fish.

Some species are said to eat paper of books, but it is more than likely that they eat the paste which fastens the leaves.

We kept a silver fish in a jar for 9 months, feeding it on paste which was given in the form of coatings of paste on small pieces of paper (we dipped the paper strips in paste). These pieces were nibbled by the silver fish.

Another time we found a silver fish swimming round in a jar of water. We rescued it, but found that it went back to the water again almost immediately. We left it there and on our return some hours later it was gone. Whether it was able to get out or was rescued by some one else is still a mystery.

The second Sub-family is **Collembola**, less known

to the average person. This group includes "spring-tails," which are minute creatures, white or cream in colour, and seen hopping about after rain or in damp weather. Those that leap do so by means of two elongate processes at the under-side of the anal end of the body. These are said to act like a spring. They seem to leap at random. They are elongate insects very like small grubs with curved abdomen and large head. There are not more than 6 abdominal segments. On the under side of the body near the first segment is a "ventral tube," the use of which is unknown, but which is an important feature of the group.

Lipura is the common Australian type. (Plate 3. Fig. 3.)

ORDER ORTHOPTERA.

This order includes Cockroaches, Grasshoppers, Mantids, Phasmids, Crickets, and Earwigs. The name, orthoptera is derived from the Greek word *Orthos*, straight, and *Pteron*, a wing. This refers to the manner in which the wings are folded and placed straight along the body. Some of the largest insects occur in this order.

They are sometimes placed in two groups: A., **Cursoria** or Running Orthoptera, example: Cockroaches, Earwigs, Mantids, Phasmids, with hind legs little different from the others. B. **Saltatoria**, or Leaping Orthoptera, with hind legs suitable for leaping; *ex.*: Short-horned Grasshoppers or Locusts, Long-horned Grasshoppers or Phasgonurids, Crickets.

Characteristics of Order Orthoptera:—

Insects with four **wings**—wingless forms common. The front pair is tough and horny, or parchment-like, and is not used much in flight—these protect the hind wings, and are termed **tegmina** (Plate 3, Fig. 4). The hind wings are flimsy and transparent, like an open fan when expanded, and folded like a closed fan when not in use. (Plate 3, Fig. 5.)

In many insects of this order the flying wings are beautifully coloured: this is seen in the phasmids; one of the large green leaf-phasmids having the daintiest pink wings, while in a long stick-

phasmid the large handsome flying wings are of a mottled brown colour. Some of the short-horned grasshoppers also have beautiful flying wings in tones of yellow, orange, and brown.

Some of the phasmids have short tegmina, and long flying wings: in this case there is a linear band of the flying-wing which is hard and is exposed: the softer part of the flying-wing folds under this.

Note that most flying-wings in this Order have a harder supporting band in the upper part of the wings.

The Orthopterous insects on the whole have not good flight, and in any case it is the male which usually has the stronger flight. One exception to this rule is the plague locust which flies across the country and ruins crops. This insect is armed with special internal air sacs which enable it to keep up sustained flight in its migrations. Orthopterous insects rely on peaceful means of defence, showing protective colouration; such can be seen in the short-horned grasshoppers. Those which fly across the country are mottled in colour and can hardly be distinguished from the colour of the ground: or in other species they resemble blades of grass. Phasmids have protective mimicry of sticks and leaves (hence called leaf and stick insects). Phasgonurids which have long antennæ, resemble leaves. Cockroaches take another means of evading an enemy—they decamp, and being narrow and compressed vertically, they can slip into cracks. Phasmids and mantids show great muscular con-

trol and this further increases their resemblance to leaves or sticks, for they remain in the one position for an hour or more.

The **mouth parts** are developed for biting and chewing and the palpi are very prominent. (Plate 1, Fig. 2.)

The **Metamorphosis** is incomplete, the newly-hatched larvæ being similar to their parents, but are wingless and are not fully developed. (Plate 7, Fig. 1.)

The insects named all possess these general characteristics but differ from one another in certain parts; hence it is necessary to put each into a family of its own, which we shall study separately. The Orthoptera comprises insects which are foes and not friends of man, the one exception being the mantid family.

GROUP CURSORIA.

(Non-leaping Orthoptera, including Cockroaches, Mantids, Phasmids, Earwigs.)

FAMILY BLATTIDÆ.

(Cockroaches.)

(Plate 4, Figs, 1, 2, 3.)

The distinguishing features of the members of this family are:—The oval body, flattened from above as if compressed by a heavy weight; the slender spined legs; and the long coxæ: the head is bent over on to the under or ventral surface.

The flattened body will probably lead us to conclude that the cockroach lives where space is limited. This we find to be true, for its haunts are in crevices in buildings, under the bark of trees, in decaying timber, under stones, etc. The slender legs will further suggest that it is capable of rapid movement, and from the uniformity of these legs we infer that it is a runner and not a leaper, hence it belongs to the Group Cursoria.

Cockroaches vary in colour from dark brown to black. A great number are wingless, and by the inexperienced these are mistaken for beetles or wood bugs.

The life of a cockroach varies, some species maturing in a few months, while others are said to

take five years. Two or three types are familiar to all; one, a large light brown insect—the domestic cockroach (*Periplaneta Americanus*) comes to us from America. Another household species is P. Australasiæ.

For general description and life history we shall take the domestic cockroach, *Periplaneta Americanus* as a type of the whole family. This is a light brown winged form, measuring over an inch in length. It is frequently seen at night, suddenly flying into the room, or running across the floor. It is often met with on our footpaths in cities and towns.

The **head** is small and is bent under the first division of the thorax, which seems to act as a shield for it.

The **antennæ** are long and thread-like, frequently much longer than the body itself. (Plate 4, Fig. 1.)

The **mouth** is the typical biting mouth of insects. (Plate 1, Fig. 2.)

The tiny appendages surrounding the mouth can be well seen if the insect is put on its back, and the mouth just touched with a straw, when instantly the jaws, maxillæ and palpi will be put into motion.

There is one pair of large compound **eyes**, oval or slightly kidney shaped. (In some varieties two ocelli or primitive eyes are present.)

The **thorax**: only the first segment of the thorax is visible. This is almost triangular in shape. The second and third segments are hidden under the wings.

The front pair of **wings** is opaque, the hind pair

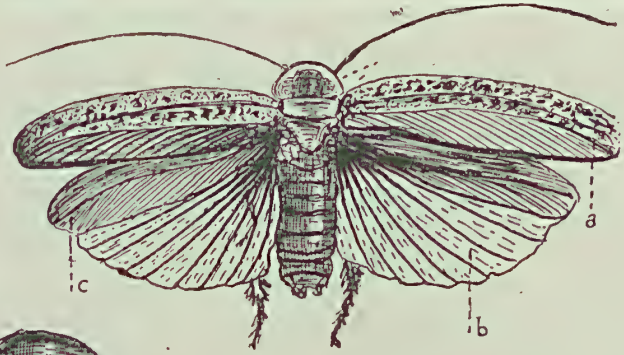


Fig 1. Winged Bush Coachroach
a. Cover Wing.
b. Flying Wing.
c. Thicker band.

Fig 2. Wingless Coachroach. (Polyzosteria)

Fig 3A. a. Egg case

Fig 3. Egg Capsule.
a. Serrated edge.

Fig 4. Locust laying Eggs (after Riley).
a. Eggs.

Fig 5. Locust Laying Eggs.
Surface View. (After Riley)

Fig 6. Egg Case (After Riley)
a. Eggs.
b. Egg Cover.

Fig 7. Egghole of Locust. (After Riley)

is flimsy and covered by the front pair, in repose. There is a stronger band in the front area of the hind wings. (Plate 4, Fig. 1, c.) The lower part of the flying-wing is fan-shaped.

The three pairs of legs are long, slender and spined on the under edges. The coxa or first division of the leg is much longer than in most insects. It lies flat along the under surface of the body when the insect is not in motion, and may be mistaken for the femur or thigh region. The foot ends in a pair of claws.

The **abdomen** is made up of a number of ringed parts, 10 in all, but those towards the end of the body overlap one another, so that to the casual observer 8 only appear. On the under surface and towards the sides may be seen 8 pairs of breathing pores, one pair on each of 8 segments.

Near the end of the abdomen is a pair of small spine-like structures called **cerci.** In the male there is an additional pair called styles.

Life History of the Domestic Cockroach.

(*Periplaneta Americanus.*)

The female deposits an egg case (Plate 4, Fig. 3) about $\frac{3}{8}$in. in length, and enclosing sixteen eggs fitted into eight separate cavities on the inside of each half of the case. This case at first is white, but rapidly changes to a light brown colour. In general shape it bears a resemblance to a small kidney bean. After a short period this egg case bursts and the tiny cockroaches come forth. They

are like the parent, but without wings, and are white and limp. The outer skin hardens, and the brown colour appears. In from nine to twelve months the cockroach is grown up. During that period it has moulted seven times, the increase in size taking place at each moult. After the third or fourth moult, the wings begin to show as tiny pads, and at the seventh moult they are fully developed.

Sometimes a much longer period than twelve months elapses before the perfect state is reached, but this depends much on the weather, and on the food supply. The food of the cockroaches consists of decayed animal and vegetable matter, paper, paste, etc. In fact, they will eat almost anything, and may be looked upon as scavengers.

We sometimes become conscious that these creatures have passed over food by the odour left behind. This odour is due partly to a fluid coming from the mouth, and partly from scent glands situated between the segments of the abdomen.

Nature frequently provides her own remedies for insect pests, and in this family the wasps are the most to be feared. One wasp (*Evania*) is found laying its eggs in the egg case of the Cockroach. Man, however, has to resort to methods where results are more quickly seen. Borax sprinkled freely in infested parts proves most effective. An instance came under our notice in which an old stone building with a stone floor was over-run with our own smaller cockroach. Several pounds of borax were used, being sprinkled freely in the cracks of the floor,

and allowed to remain there for two or three days. Then this was swept up, and a fresh supply put down. In a month's time the building was quite free from the pest, and there was never a recurrence.

Poisoned paste or food is often put down at night, but this is specially dangerous where children are concerned.

Belt says in "Naturalist in Nicaragua," "The Cockroaches that infest the houses of the tropics are very wary, as they have numerous enemies, birds, rats, scorpions and spiders; their long trembling antennæ are ever stretched out, vibrating as if feeling the very texture of the air round them; and their long legs quickly take them out of danger. Sometimes I tried to chase one of them up to a corner where on a wall a large cockroach-eating spider stood motionless looking out for its prey; the cockroach would rush away from me in the greatest fear, but as soon as it came to within a foot of its mortal foe, nothing would force it onwards, but back it would double, facing all the danger from me rather than advance nearer to its natural enemy."

Many other cockroaches are quite familiar. One, a much smaller light brown insect about ½in. in length is often known as the "Crotan" Bug. A black wingless type (*Panesthia laevicollis*) measuring about 1¼ inches long and with a small compressed head, is met with in great numbers under the bark of dead timber, and in rotten logs. Another large brown, wingless variety (*Polyzosteria limbata*) (Plate 4, Fig. 2) has the edge of the body

outlined with yellow. It is met with in the coastal districts of New South Wales.

One of our largest wingless forms is *Polyzosteria pubescens*. It closely resembles the one just described, but is of a uniform brown colour, 2 inches long and 1½ inches wide.

The giant among the cockroaches is a large bright reddish-brown wingless insect 2½ inches in length, and 1½ inches across the body.

Most of the Cockroaches are well known by popular names in the districts where they are numerous.

Sharp thus writes: "The Common Cockroach (*Blatta*) is a rather amusing pet, as the creatures occasionally assume most comical attitudes, especially when cleaning their limbs; this they do somewhat after the manner of cats, extending the head as far as they can in the desired direction, and then passing a leg or antennæ through the mouth; or they comb other parts of the body with the spines of the legs, sometimes twisting and distorting themselves considerably in order to reach some not very accessible part of the body."

Family.—Praying Insects (Mantidæ.)

(Plate 5.)

The term "praying" is applied on account of the devout attitude assumed when the insects are about to seize their prey. The front legs are drawn up, and the fore leg is held at an acute angle to the thigh in front of the head, giving altogether a reverent appearance.

The Mantidæ may be readily distinguished from

other families of the Orthoptera by the following characteristics:—

The triangular head, viewed from the front, movable on a neck region. Viewed from side or back, the head is elongate. The long prothorax is usually laterally longer than each of the other divisions, the strongly developed raptorial (fitted for seizing) front legs, (Plate 5, Fig. 2 a), and the jointed cerci on the end of the body are also distinguishing features.

We will take the common green Mantis (*Orthodera ministralis*) as a type of the family.

The length from the head to the end of the body is about 1½ inches. The head is triangular, with tiny, bright bead-like eyes standing out at two corners of the triangle. The antennæ are short, and the mouth parts are well developed. The quickness with which the head can be turned is most marked. Two pairs of wings are present. The front pair is green and opaque; the hind pair larger and each folded in the characteristic fan-like way beneath the front wing.

The legs are not uniform in size, the front pair is much larger and stronger than either of the other pairs. These front legs are spined on the under surface, and a kidney-shaped bluish purple mark is present on the tibia of each. The abdomen has a somewhat flattened appearance from above.

Life History of Green Mantis.

(*Orthodera ministralis.*)

The eggs are deposited in a lozenge-shaped

mass which is fixed to the side of a stem, but sometimes they have been seen on fences, or even on the surface of rocks. (Plate 5, Figs. 4 and 5).

On the upper surface are two longitudinal rows of alternating "doorways" or openings, through which the young mantids escape. Each doorway leads into a narrow, laterally compressed egg chamber which in the broader part of the mass, holds four, elongate, vertically placed eggs. We found eight double rows of these, and at the narrower ends of the mass, a few smaller egg chambers, holding three, two, or one egg, according to their space. The eggs do not fill the entire chamber but extend only for two thirds of the distance upwards. In the upper part is a plug of fine spongy material through which the emerging mantid cuts its way, when escaping. There is a strong outer wall enclosing all these egg chambers. We cut cross and longitudinal sections through several of these nests, and examined them with the lens.

The young mantid (Plate 5, Fig. 6) frequently casts its first skin as it emerges from the egg. It is like the parent in general shape, but without wings, black in color, and less than $\frac{1}{2}$ inch in length. It can move freely, and at once begins to look around for food; if this is scarce, it quite willingly devours its fellows. It soon changes to a delicate green color. After the third or fourth moult, the wings begin to appear, and then gradually develop till the perfect state is reached.

The life history of the green mantid can be followed out quite readily. We have collected the

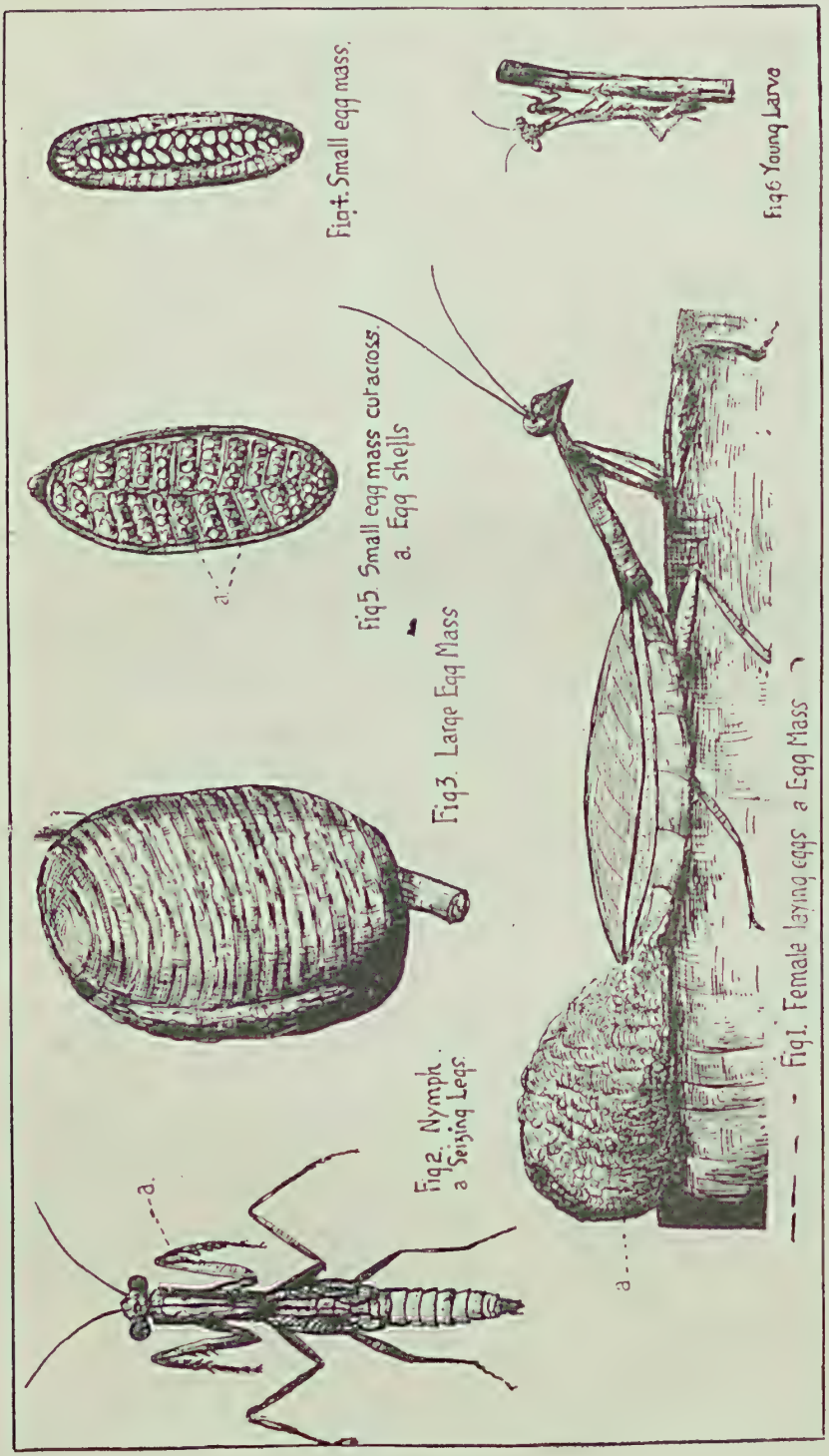


Fig4. Small egg mass.
Fig5 Small egg mass cut across.
a. Egg shells
a
Fig3. Large Egg Mass
Fig6 Young Larva
Fig2. Nymph.
a Seizing Legs.
a
a
Fig1. Female laying eggs a Egg Mass

MANTIDS.

egg masses and placed them in a closed vessel such as a glass jar, the top of which we covered with a piece of fine net. When the baby mantids appeared, we placed small pieces of a rose bush, which were covered with aphides, in the jar. Then commenced a procedure worth watching. The mantids simply slaughtered and devoured the aphides in the most ruthless manner. As a result of such feasting, they grew rapidly, and cast off skins were seen in numbers. Many perished when about ¾ inch long. Fearing we should lose them all, we placed the remainder on a rose-bush growing so close to the doorway, that we saw our mantid friends daily, and had the pleasure of seeing some of them reach maturity on the rose bush on which they had been placed.

Besides the green mantid just described, there are many others quite common. A large brown species (*Archimantis latistylus*) measuring from 3 to 4 inches in length, is frequently met with on the low shrubs of our coastal bush. It has beautiful eyes, resembling opals—of a mottled, greenish-blue color. The life history is practically the same as that of the green mantis, except that the egg mass is covered with a cream papery-looking material, which, as a frothy mass, was secreted from the insect's body, but became tough on exposure to the air. The whole structure is about ¾ inch long, and somewhat cylindrical in shape. (Plate 5, Fig. 3.) Many who come across it firmly fastened on to the side of a twig, think a spider was the originator.

Sharp says: "The female places the extremity of the body against a twig or stone, and emits some foam-like matter in which the eggs are contained. This substance dries. Whilst attaining a sufficient consistence, it is maintained in its position by the extremity of the body, and the tips of the elytra (coverwings), and it is shaped and fashioned by these parts. The eggs are not, as might be supposed, distributed at random through the case, but are lodged in symmetrically arranged chambers, though how these chambers come into existence by the aid of so simple a mode of construction does not appear."

A large green and brown mantid (*Tenodera australasiae*) has the hind wings mottled with brown and shaded pink toward the inner margins. A few small types of mantids are wingless. These are frequently seen on the ground which they closely resemble in color.

The food of all mantids consists chiefly of insects, such as flies, moths, aphides, scales, etc., spiders, and other small animals. It is interesting to watch a large moth being captured. The mantid watches much as a spider does when on the look-out for a fly. When the unwary victim approaches, the front legs which have been held in readiness, shoot out and seize the insect, shake and crush it, and then proceed in preparing it for a final dissection. The audacity of some mantids in attacking large insects is simply amazing. Size never seems to deter them if appetite needs satisfying. We saw a mantis attack a large spider.

We seized the mantis and placed it on a twig near by in order to observe it more closely. During this process the mantis stopped devouring the spider, but held it in its right arm-like front leg, just as one would place a book under one's arm. After a pause, it finished its meal and dropped the shell of its victim.

The chief enemies of the Mantidæ are birds, parasitic wasps and flies. The wasps and flies deposit their eggs in the egg masses of the mantids, particularly in the larger rounded ones.

Mantids have protective coloration to a more or less degree, for the green mantids are the color of foliage leaves, and the brown ones are not unlike twigs. This is not nearly so striking as one sees in the Phasmids, or Leaf and Stick Insects.

It has been recorded that one Indian mantid imitates the form and color of the corolla of a flower in order to entice insect visitors to the "flower" which it promptly seizes.

The Mantidæ are man's insect friends, and it is probable that if numbers could be placed on aphis and scale-infested plants, they would prove very effective.

Family Phasmidæ.

(Leaf and Stick Insects.)

(Plate 6.)

The name "Stick and Leaf" Insects has been applied on account of the striking resemblance which many of the members of this family bear to either sticks or leaves. It is curious, too, that in

Fig 2. Leaf Phasmid

Fig 3 Egg of Phasmid

Fig 1 Stick Phasmid
a. Short Prothorax
b. Cerci in one piece

PHASMIDS.

many cases the limbs stand out at such an angle as to make the resemblance still more striking, and in some species of stick insects the creatures sway at times, just as leaves and twigs would move in a breeze

The resemblance to leaves and sticks is more remarkable on the whole, in the females which are usually much larger than the males. The males are better fitted for flight. Many phasmids have very beautiful flying wings, many with brilliant coloring. In some cases the tegmina are short, in others they are long and leaf-like or twig-like in general color.

If numerous these insects can be very destructive. The young student may at first confuse the phasmids with the mantids, but on studying the characteristics and habits of each, the differences can be seen.

Note the head is rounded and not movable on a neck region. The first segment of the thorax is short, and the second long. The front legs are not more strongly developed than the second and third pairs for these insects are vegetable feeders and do not want raptorial legs. The cerci are not jointed.

Some phasmids are said to eject an evil smelling, pungent fluid from the thorax, when disturbed. The eggs are not laid in egg masses such as we find in the mantids. The mother phasmid just drops them haphazard from the trees to the ground. These eggs resemble seeds for they have a hard, dark-colored coat with a little rounded knob at the

apex. (Plate 6, Fig. 3.) The egg is very tiny for such a large baby insect to emerge, but this seems so because the baby phasmid on emerging can expand the segments of the body.

E. Step thus describes the emergence of a phasmid: "Now the egg capsule measures 3 mm in length, and the newly-emerged "Stick" is 10 mm in length of its body, not taking the long antennæ and legs into account. Of course, the discrepancy in size between the capsules and the young is explained by the fact that considerable expansion has taken place during actual emergence.

Before emergence, for example, the three legs are fairly close together, but during the struggle to free itself from its prison, the two hind joints of the middle body (meso and metathorax), lengthen and separate the legs considerably."

The wings of the winged forms consist of a pair of more or less linear cover wings or tegmina, which are hardened at the front edge. The hind pair of flying wings is variously colored and beautifully netted; they are folded fanwise ex *Podacanthus*. Wingless forms are seen in *Bacillus* and *Extatosoma*. Perhaps the phasmid which we most often see is a large green insect, popularly known as "Laurie's Ringbarker" (*Podacanthus Wilkinsoni*). This measures from 6 to 8 inches from the head to the tip of the abdomen. The body seems to broaden out in the thorax, and to taper toward the end. The head is small and rounded. The antennæ are short. One pair of eyes is present, also the characteristic biting mouth parts.

The front pair of wings is short, only partly covering the hind pair; the latter are rather horny along the upper edge which acts as a protection to the flimsy fan-like part when closed. The inner portion of the hind wing is shaded from green to a delicate pink.

When this insect is flying, it is almost bird-like in wing expanse.

The legs are all the same size. The abdomen is many jointed, and has a pair of cerci at the end. (Plate 6, Fig. 1. b.).

Life History of the Green Phasmid.

(*Podacanthus Wilkinsoni.*)

The eggs are deposited singly on the ground among dried leaves about February or March. They are brownish green in color, about 1/5 inch in length, rounded at the base, and flattened at the upper end, which is surmounted by a knob, which looks much like the top of a tiny lid.

The eggs remain on the ground during the winter, and the young phasmids come forth in early spring. In some cases, the eggs lie dormant for two seasons.

By January or February, the phasmids are full grown, having passed through a series of moults in reaching the adult stage.

A phasmid we had in captivity passed through its final moult. The cast-off skin was perfect even to the eye coverings and antennæ. The first rent appeared over the back of the thorax and extended forward. The head and front legs were pulled

forth first, then these latter were used to help set the remainder of the body free from the old dress. The insect looked damp and limp in the new skin, but this soon became firm and hard.

Another phasmid we had under observation deposited 5 or 6 eggs. Great numbers of the green phasmids described often attack areas of well-timbered country, denuding it of leaves. They seem to be partial to the *Eucalyptus*. The name "Laurie's Ringbarkers" arose from the fact that a few hundred acres belonging to a squatter named Laurie were rendered leafless, and even the bark of the trees was not exempt from their ravages.

It is hard to devise any means of dealing with a pest of this nature. No doubt they have a few parasitic enemies and birds, and lizards probably devour them.

A large greyish brown stick-like insect (*Acrophylla titan*) used to be very common around Sydney before so much of our scrub country was cleared. It was popularly known as the "Walking Stick" Insect.

The female measures about 8 inches from head to tip of abdomen.

The front wings are blue black. The hind wings are brown, shaded to rose pink at the base.

The male is slighter in build than the female.

Another striking member of this family is the "Green Leaf" Insect (*Extatosoma tiaratum*), Plate 6, Fig. 2), with leaf-like expansions on the legs, and with the end of the abdomen also flattened out so as to look like a leaf. When at rest on the

foliage of a plant, it is indeed very difficult to pick it out. We have noticed this phasmid still further carry out the resemblance between it and its surroundings by keeping up a slight swaying movement much as leaves would if moved by a gentle breeze

We had one of these "green leaf" insects sent to us, which was found on a peach tree affected by woolly aphides. The leaves of the tree were mottled yellow and green, the same yellow and green mottling was carried out in the phasmid.

These insects have wonderful muscular control, which enables them to further imitate sticks and leaves by remaining quite still for long periods of time.

Family—Earwigs (*Forficulidae.*)

(Plate 7, Figs. 6, 7 and 8.)

The popular name of this family seems to have arisen from a mistaken idea that these insects had a habit of getting into the human ear during sleep. Another theory concerning the name is that it may have come from the ear-like structure of the hind wings, (Plate 7, Fig 7), but exactly why the name "earwig" came to be applied does not seem quite clear.

The scientific name is derived from the Latin—*forficula*—scissors, such term relating to the scissor-like structures on the end of the body.

The earwigs may be distinguished by the rounded head, short, front wings, (Plate 7, Fig. 6) which scarcely extend beyond the thorax, leaving the ab-

Fig1 Larva of Locust
a Leaping Legs.

Fig2. Nymph of Locust
a. Wing Pads

Fig3 Larva of Longhorn

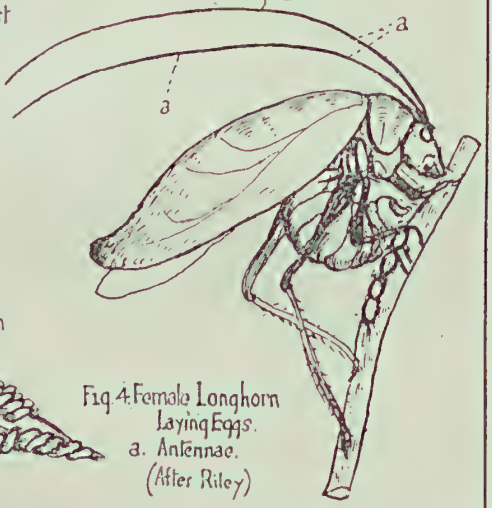


Fig 4. Female Longhorn
Laying Eggs.
a. Antennae.
(After Riley)

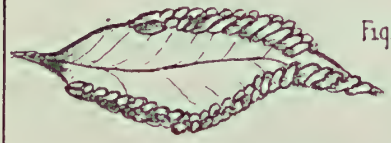


Fig.5 Eucalyptus leaf with 2 Rows
of Eggs of Longhorn

Fig 6. Winged Earwig
{a. Wing covers
{b Callipers

Fig 7 Flying Wing

Fig 8 Wingless Earwig
(Anisolabis).

GRASSHOPPERS AND EARWIGS.

domen quite uncovered; the strangely folded hind wings which are rarely seen, and the pincers or callipers (Plate 7, Fig. 6) at the end of the body.

A large reddish brown type (*Labidura truncata*) is well known. It measures about 1 inch in length, and like most earwigs, may be found in damp places, such as under stones and logs.

Parts of Body.—The head is round, with one pair of compound eyes, 2 long antennæ, and one pair of maxillæ (mouth structures) extending in front of the head. The mouth is typical of Orthopterous insects.

Legs.—The three pairs of legs are uniform in size. The front wings look like tiny oblong pads placed over the back of the thorax (Plate 7, Fig. 6 a.), under these pads a pair of flimsy complex hind wings is folded, first fan-wise, and then doubled back. No other insect has such complexly folded wings. It is seldom that these wings are seen, as they seem to be used but rarely for flight. It is even a difficult matter to try to pull them out from their resting place with a needle.

The abdomen is generally reddish brown in color, but shaded to a yellow at the sides. The terminal segments are barred with reddish black. There are 10 segments in the male and 8 in the female.

The pincers or callipers are teethed on the inner edge, and meet at the end. These structures are harmless, and are often carried turned back over the body. They are not known to be used in attacking enemies. They may be of use to the insect

in protecting itself, or in opening or in packing the wings. These forceps or callipers vary much in the male earwigs.

Life History of Large Brown Earwig.
(*Labidura truncata.*)

The eggs are deposited in the ground, and the young come forth in early spring. The baby earwigs resemble the parent in general shape, but are without wings. (In the wingless forms the larvæ can only be distinguished by smaller size and softer integument.)

At first the antennæ consist only of a few joints, but increase to 13 or 14 in the perfect insect. The adult stage is reached by a series of moults. The wings begin to appear after the fourth moult. We have observed the great concern which the mother earwig shows for her young, never leaving the tiny burrow in which the eggs have been placed, until the young are hatched. She then broods over the little company much as a hen would over her chickens, trying to get them under her own body at the slighest approach of danger.

Few insects show such maternal care, for many parents die before the young leave the egg, and then mother nature is the only nurse they know.

Their food consists of decaying vegetable or insect matter, and even small living insects are attacked. Many small types of earwigs exist. One is distinguished by having the pincers of unequal length. Some are wingless. An Australian wingless type is *Anisolabis* (Plate 7, Fig. 8.)

We found an earwig's nest in January. There were about a dozen nests just near a damp log sheltered by grass. We lifted the grass up, and saw the nests on the damp ground. In one nest there was a father-earwig with curved pincers, and mother-earwig with straight pincers, and small earwigs in various stages of development. Some tiny ones were quite white, others had the abdomen brown, while head and thorax were white. Others had head and thorax white, while tail-part only was brown. Eggs were present in the nests, and when we disturbed them, the mother and father seized some of the eggs, and tried to get away with them. They moved them to a new spot some 6 inches away and in about 15 minutes had removed all the eggs. We covered them over with grass and left them in peace. There was a cluster of Nasturtiums growing near the log and we found earwigs in nearly every flower as many as three being in one flower. They did not seem to be eating, but just resting.

Observations on Earwigs.

On disturbing some decaying boards which had been lying on damp earth for some time several nests of earwigs were observed in little hollows made in the rotting timber. The nests were in hollows of about an inch long and from $\frac{1}{8}$ to $\frac{1}{2}$ inch in width. On lifting the upper board (there were 3 superimposed boards), a nest was observed with dozens of tiny white eggs about the size of a small pin's head. The mother earwig at once rushed above the eggs and showed great concern.

She could not cover them all with her body, but she did her best by moving first to one side and then to another. We placed the board gently back, and left it for ten minutes; on returning, all but about a dozen eggs were removed, and no earwig was in sight. We lifted the second board and found the nest with the majority of the eggs safe in a new hollow. There were cracks in the soft wood which allowed the mother to quickly remove the eggs farther from the scene of disturbance. This time she began to gather up the eggs and yet seemed loathe to leave the mass of them. She seized one in her mandibles, then dropped it, then picked up another, and in trying to pick up two more dropped all, but she would not leave the bulk of the eggs while we watched.

Family—White Ants (*Termitidae*).

The exact position of the White Ants among the insects is very doubtful. Formerly they were put in with the Neuroptera. More recent writers are inclined to give them a place with the Orthoptera, others again think that they do not sufficiently agree wtih either, and place them in a separate order—the **Isoptera.** We shall consider them among the Orthoptera, though they differ from the order in many respects, yet resemble it in having biting mouths parts, and gradual development.

The White Ants are social insects, living in communities composed of different castes—males and females, workers, soldiers and queen. The normal males (Plate 8, Fig 5) and females are

winged, and have eyes. They are brown in color, and the wings are about twice as long as the body; they only remain in the home a very short time after the wings have developed. The workers cut openings in the side of the nest, and towards dusk on very hot summer evenings, one may see countless numbers of the winged male and female termites swarming forth. Later on they may be seen flying around the lights inside the houses, and dropping their brown wings, which break off very readily along a distinct junction line. After they have lost their means of flight, numbers pair off in order to found a new colony, but the majority perish. The female now becomes the queen of the little company. Her body develops into a huge egg sack, varying in different species from one to five or six inches in length. She is waited on by the workers and her royal mate; the former carry the eggs away to specially prepared cells.

The workers (Plate 8, Figs. 1 and 2) form the most important part of the community, both in point of numbers, and in the amount of work they do. They are white, blind, wingless, provided with a large, round head, a pair of antennæ, and huge biting jaws. They do the work of the home, get the food, rear the young, and build the nest.

The soldiers closely resemble the workers, but have a longer head, and more formidable looking jaws. They, too, are blind and wingless. Their duty seems to be in guarding the home. The workers and soldiers are imperfect males and

Fig 1 Soldier-worker

Fig 2. Worker

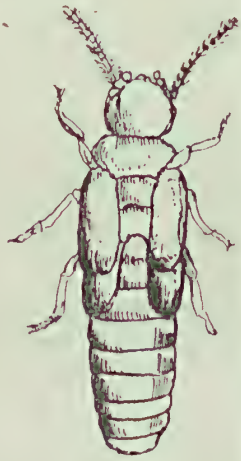


Fig 3. Nymph

Fig 4 Queen

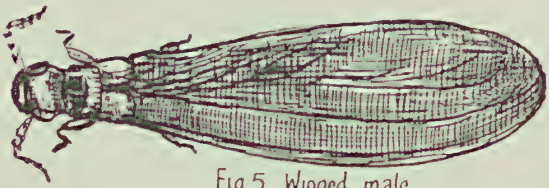


Fig 5 Winged male

Fig 6. Queen in cell

WHITE ANTS (Enlarged) AFTER FROGGATT.

females whose development apparently is arrested and modified.

Now, shall we return to the queen in her royal apartment, and endeavour to trace the life history of the various castes we have mentioned. The tiny white eggs which closely resemble grains of sugar to the casual observer, are carried into special cells. The small white forms which come from the eggs, are fed and tended by the workers. These in time develop into workers, soldiers and winged males and females. The wings of the males and females appear towards the final moult, the intermediate stage being spoken of as the nymph.

White Ants vary in size according to the particular genus to which they happen to belong.

They all feed upon timber.

The home of the White Ant is called the termitarium. This may be a huge rounded mass projecting from the sides of trees, or built over stumps or even rising from old logs in or out of the ground. Along the Southern railway in New South Wales, particularly between Bowral and Goulburn, great numbers of these head like masses may be seen in the open paddocks. In Northern Australia they are often found 20 feet in height. The hard brown papery mass of which the nest is composed is formed by the insect chewing up wood, and then mixing it with particles of earth. Numbers of rooms or galleries make up the whole, each having its particular use.

The cell of the queen mother (Plate 8, Figs. 4 and 6) is large with a small entrance. She cannot

leave this cell after she has developed and become so large. The nursery is close by, and as the young develop, they are transferred from one set of rooms to another. Some termites do not build a nest of the type described, but found a home at first in the ground, then hollow out galleries in some overlying timber. Paling fences and wooden houses built on the ground are often completely destroyed in this way. The outside of the wood as a rule is left intact, the whole of the inside being eaten away, except for very flimsy partitions which separate the galleries. If it becomes necessary for work to be carried out on the outside of timber, it is done under shelter of a tiny saw-dust cemented cover. These insects truly love darkness rather than light.

Few timbers in Australia are exempt from their attacks. Cedar, red and white mahogany seem almost proof against them. Iron-bark does not always remain free from their ravages. On the northern rivers of New South Wales, and in Queensland, where so many houses are built of wood, we find that the portion below the floor is not enclosed, thus leaving the piles exposed to the light and air, and to a great extent keeping out the white ants. Piles too are often capped with zinc or tin. Timber for building purposes is frequently treated with wood preserving oil or paint in which a percentage of arsenic to a gallon of oil has proved a most effective mixture.

GROUP SALTATORIA.

(Grasshoppers, Crickets.)

Grasshoppers.

This family can hardly be described as a whole, as certain members possess certain distinctive features not seen in others, but the roof-like body, biting mouth parts, and strongly developed hind legs are common to all.

We shall therefore place the Grasshoppers in two divisions or families, and the student can quite easily note the points of resemblance on which the classification is based.

1.—Short-Horned Grasshoppers.

Family Locustidæ.

(Plates 4 and 7.)

(This family is referred to as Family Acridiidæ in most text books.)

Characteristics.—

(a) The antennæ are short and composed of less than 30 joints.

(b) The ovipositor consists of four short flattened blades, and is quite inconspicuous.

(c) The tarsi are three jointed.

(d) The hearing apparatus is situated on the

first segment of the abdomen (Plate 3, Fig. 7, a.), just behind the junction of the hind leg.

The short-horned grasshopper is really the true locust, and when the term "locust" is met with in scientific writings, this grasshopper is referred to and not the cicada to which the name locust is so generally applied in Australia.

If we carefully observe one of these grasshoppers, we shall see that the head is at right angles to the body, and the mouth is towards the surface on which the insect rests. The little jointed structures surrounding the mouth can be well seen if the insect is turned upon its back, and if they are touched with a straw their movement in eating may be noted.

The first segment of the thorax looks like a protecting shield over the roof-like body, and partly over the head.

The front wings are frequently called the tegmina. They are horny and opaque along the outer edge. (Plate 3, Figs. 4 and 5.) The hind pair forms a pretty fan when expanded, and lies like a closed fan when at rest, being protected by the overlapping front pair.

The first and second pairs of legs are equal in size, but the thigh of the third pair is enormously developed for hopping purposes (Plate 7, Fig. 1a).

The abdomen as a rule is covered by the wings, but we meet a few types with short wings and others again that are wingless. Short-horns are the strongest in flight in the Orthoptera and possess

special structures known as air sacs connected with the tracheæ.

The four short pointed processes forming the ovipositor of the female, though not conspicuous, can be easily observed.

The noise made by the short-horned grasshopper is produced by scraping the rough surface of the hind legs along the edge of the front wings.

As a rule, the colour of the grasshopper harmonises so beautifully with its surroundings, that unless the insect is seen on the wing, it can hardly be noted.

Life History of the Short-horned Grasshopper.

The eggs are deposited in the soil a half inch or more below the surface. (Plate 4, Figs. 4 and 5.) From twenty to thirty eggs may be deposited in one batch by one female, and several batches may be laid in one season. The eggs are surrounded in the soil by an exudation forming a frothy case. (Plate 4, Figs. 6 and 7.) In the case of one species a little company of males may surround the female during the egg-laying process. In summer, the eggs hatch in about a fortnight. The young (Plate 7, Fig. 1) is like the parent but without wings, almost black in colour, not more than one-sixth of an inch in length, and capable of hopping an inch or two. Development takes place by a series of moults. The wings begin to appear when the insect, called now a nymph (Plate 7, Fig. 2), is half grown, and then the permanent colour soon shows. The adult stage is reached in six or seven weeks from the

time the insect leaves the egg, and its life as a fully grown insect is rarely longer than six weeks.

From time to time certain types of grasshoppers appear as plagues, destroying every vestige of vegetation that happens to lie in their track. They move forward as a seething mass, rendering grass paddocks almost as bare as the roadway. Nature to a limited degree has her own remedies. In a cold, wet winter, great numbers of eggs are destroyed by frost and rain. Birds, beetles, and wasps are also enemies of the egg stage.

A parasitic fly (*Sarcophaga aurifrons*) lays its eggs on the adult grasshopper, and the larvæ devour the soft parts.

Birds, perhaps, are responsible for ridding us of the greatest number. The quantity taken from the crop of an Ibis or Brush Turkey is amazing.

Some species of plants, such as *Delphinium*, are poisonous at times to the grasshoppers.

Locusts are very tenacious of life, and can be submerged in water for some time and yet revive.

When the grasshopper becomes a plague in any district, more speedy remedies, however, than those already mentioned have to be resortd to. A heavy roller passed over the ground in the hopping stage, before the wings have developed, has proved a useful check.

A good contact spray can be made from kerosene, soap and water, in the proportion of 1 gallon of kerosene, 1 or 2 lbs. of soap, and 7 gallons of water. The soap is dissolved in 2 gallons of boiling water,

and while this is still hot, the kerosene and the remaining water are added.

Poisonous arsenious sprays may also be used, but where this is done, all stock must be kept out of paddocks for a week or two.

For detailed account of various species of Grasshoppers, see Froggatt's "Insects of Australia."

2.—Long-horned Grasshoppers.

Family Phasgonuridæ.

(Plate 7, Figs. 3, 4, and 5.)

(Usually referred to in text books as the Locustidæ.)

It would perhaps be more correct to call these treehoppers, as they are found, not on the grass, but on the foliage of trees. In American writings they are known by the popular name of katydids, because their chirping noise seems somewhat to resemble this word.

They may be distinguished from the short-horned grasshopper by the following distinctive features:

(a) Exceedingly long antennæ, more than 30 joints, and often extending far beyond the body. (Plate 7, Fig. 4, a.)

(b) The organ of hearing is not situated on the abdomen, but on the tibia of the first pair of legs. (Plate 3, Fig. 6, a.)

(c) The ovipositor is prominent and spear-shaped. (Plate 3, Fig. 8 a.)

(d) The tarsus is 4 jointed.

In general structure, the treehopper closely resembles the short-horned grasshopper. When wings are present they are usually much longer than the body, and have a decided leaf-like venation. So closely at times do the wings resemble leaves, that they may easily be mistaken for them.

Many varieties are wingless.

The hind legs, though slightly larger than the other pairs, do not show the marked development seen in the true hoppers.

The noise made by these insects is produced by slightly raising the front wings and scraping a prominent vein of one upon a resonant vein of the other. In some species the females are incapable of making any sound.

Sharp thus describes the structure of the wings for making sound: "One of the wings bears a file on its inner surface, while the other, on the right side of the body, is provided with a sharp edge placed in a prominent part of its inner margin. By slightly tilting the tegmina and by vibrating them rapidly, the edge passes under the file and a musical sound is produced."

Life History of the Green Tree Hopper.

(*Elephantodita pinguis.*)

This hopper measures about 3 inches across the outstretched wings. The body is short and the wings extend beyond it. The eggs are about $\frac{1}{4}$ inch in length, dark grey in colour, and a pointed ellipse in shape. About 50 or 60 are deposited in a double

row around the edge of a leaf, or along a stem. (Plate 7, Fig. 5.) We have seen them in both positions. The regularity with which these eggs are placed is most striking. We observed that the young emerged from the upper end of the egg, and shed its first skin as it did so. The baby hopper is black, without wings, less than ½ inch in length, and with a head out of all proportion to the rest of its body. After moulting a few times, it becomes green, and wing pads begin to appear. After the final moult, the wings are full grown. It is most interesting to watch the insect getting out of its skin. At the last moult a split is seen down the back of the thorax, and the old skin below this, by means of sundry jerks and working of the body and legs, is pushed off; then that part covering the head, eyes and antennæ is got rid of. The whole process occupies about an hour. When completed the front feet are used in cleaning the head and antennæ. The life from the egg to the adult stage covers a period of seven or eight weeks; then as perfect insects they live a few more weeks.

The treehoppers are solitary insects. We have frequently seen some species conceal themselves by fastening the edges of leaves together, thus affording a roof-like shelter. On one occasion we came across a large cocoon of an Emperor Gum Moth, from which the rightful owner had long since flown. The opening was covered by a flimsy web, and on removing this we found a treehopper quite comfortable inside its appropriated home. The entrance had been apparently concealed in order to keep off

enemies to which it would readily have fallen a prey.

Treehoppers live by eating the foliage of trees, being particularly partial to the *Eucalyptus*. The Green Treehopper (*Elephantodita pinguis*) sometimes becomes a pest in orange orchards, where it nibbles the green skin of the young fruit. The scar so made heals, but appears as a brown patch when the fruit is ripe, and this to a certain degree takes from its commercial value.

An interesting treehopper called the Mountain Grasshopper (*Acridopeza reticulata*) is described by Froggatt: "both sexes are of a uniform dull brown colour, but very different in structure; the male measures 2 inches; has long pointed elytra, and well developed wings; the head is small; the antennæ slender and thread-like; the eyes stand out on the side of the head, and the thorax is saddle-shaped. The female is furnished with a very short, rounded body, richly mottled with blue, white, and red, covered with a pair of rounded, short, shell-like elytra, but the wings are wanting. When disturbed, she stands on tip-toes, arches her body, raises her elytra, exposing all the bright tints of her body, which probably act as a warning to her enemies."

Another Phasgonurid is the Wingless *Anostosoma*, which is very robust looking, with shining reddish-brown body and legs and powerful head and mouth parts. *Paragryllacris* has most beautiful net-veined wings and very long antennæ. It shows fight when disturbed. We found one in a hole in the trunk of a gum tree.

FAMILY—CRICKETS.

(*Gryllidae*) (Plate 9.)

The Crickets are easily distinguished from other families by the rounded head, brown to black colour, and by the pair of spines on the end of the body. In addition to these spines the female has a spear-shaped ovipositor. The hind legs are also spined and strongly developed for hopping. The antennæ are long and thread-like. There are usually only 3 tarsi, more rarely 2 or 4. The part of the tegima used for producing sound is larger than that in the Long-horns (Phasgonurids). The auditory organ is on the front leg as in Phasgonurids.

Life History of a Common Black Field Cricket.

Gryllus commodus.

The female places her ovipositor into the soil in varied places, depositing numerous eggs. A day or more may be devoted to this process. Each egg is elliptical, about one-tenth of an inch in length, with a tiny lid or cap on one end. After about three weeks, the young crickets appear, pushing the cap from the egg as they emerge. At first they are white, about ¼ inch long, and without wings. The colour soon changes to brown and then to black. The adult stage is reached after the insect has

moulted several times. When full grown it is almost one inch in length.

The food of the cricket consists mainly of vegetable matter in the soil, but when hard-pressed they will attack refuse and even clothing.

The chirp of the cricket is well known. The right wing cover overlaps the left, and the song is produced by the hard part of the former scraping on that of the latter. Sharp says: "The wing covers of the male differ from those of the Locustidæ (our Phasgonuridæ), as the pairs are of similar formation and each bearing a stridulating file on its lower aspect." The privilege of chirping belongs to the male only. The shrill notes are used in calling his mate.

Crickets frequently appear in great numbers in wet seasons. In flood time in coastal districts we have seen thousands of crickets hanging on to fences just out of the water, much as a swarm of bees would do.

They are kept in check by birds, lizards, and ants devouring the young, and also the eggs before they have time to hatch.

A smaller cricket less than ½ inch in length, and exactly resembling the common black cricket, is often found around the edge of lagoons when the water begins to dry up in the early summer months.

The mole cricket (*Curtilla coarctata*) (Plate 9. Figs. 3 and 5) bears a distinctive character in the front legs, which are developed into a kind of shovel (Plate 9. Fig. 4), by means of which the insect burrows rapidly in the soil, soon excavating a

home for itself. The front wings of the adult are short, whilst the hind pair is much longer, and frequently ends in thread-like tails. The mole cricket often spoils the even surface of a lawn by forming tiny mounds.

We have seen the nest of a mole cricket made of hardened earth worked up in the form of a tiny cavern, and the eggs were deposited in several clusters in this. (Plate 7, Figs. 1 and 2.) There were tiny baby mole crickets also in the nest. This was obtained about 2 inches below the surface of garden soil.

Many wingless types of crickets are to be met with.

Observations on the Mole Cricket. (Plate 9.)

(*Gryllotalpa coarctata.*)

(Taken from the "Australian Naturalist" by Mabel N. Brewster.)

On a bright afternoon in November I heard several crickets chirping, and going carefully towards the sound till I located them, I pulled up a number of plants of the Umbrella Sedge (*Cyperus*), for crickets love roots of plants. I turned over the soil and found a beautiful little "cricket home" with two little doorways leading into a tiny underground cavern about two inches in diameter. (Plate 9, Figs. 1 and 2.) Its walls were quite firm and strong and near this little home were a small and a large cricket.

I then turned over an old stump and gently scraped lumps of earth that were adhering to it, and

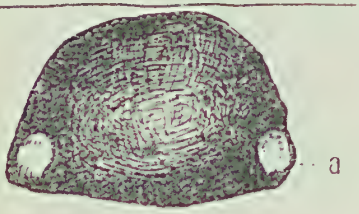


Fig 1 Egg nest
a Entrance

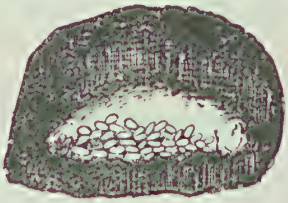


Fig 2. Eggs within nest

Fig 3 Adult
a Cover Wing

Fig 4 Front Digging Leg

Fig 5 Adult
a. Cerci

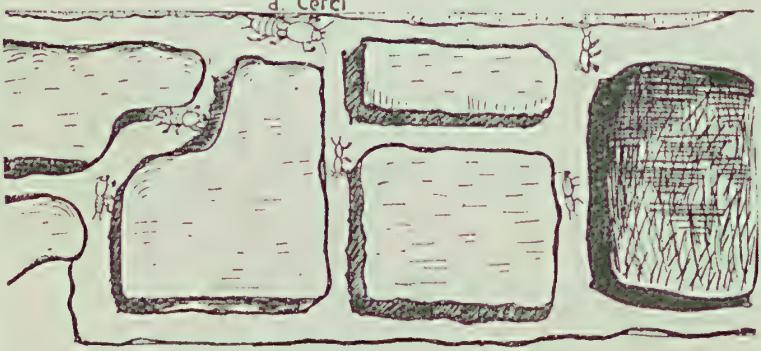


Fig 6. Home of Mole Crickets

to my surprise found that two of the lumps were little 'egg-room' caverns, each with about 200 eggs in it. The eggs were brown and rounded. In one nest were two tiny baby crickets. One was just emerging from the egg and was quite white Under the log were also crickets in all stages of development, and there were two adults. I was fortunate enough to see one of the crickets emerging. On bringing the eggs into the house, I saw one of the eggs move and watched the process with the aid of a broad lens. The egg skin was slit along the back and the tiny creature moved its head and thorax up and down, at each rising, getting further out of the egg. The head and thorax came first and later the abdomen, and the two tail pieces or cerci came last, and in this last effort it rolled the egg and itself right over.

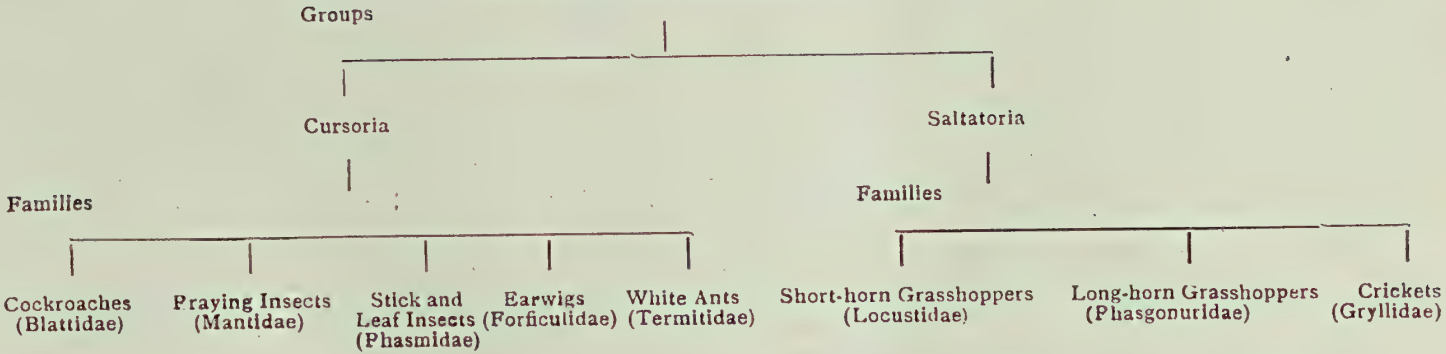
But the legs and mouth parts seemed to be connected with a fine piece of skin. For a time the tiny creature moved about like a boy on a cross-bar, bending its body right back, and then swinging forward. It would roll itself and the egg shell right over from side to side whilst making these swinging movements. The eyes shone like two pearls when seen in the light.

At last one leg was free, and I then aided it by gently separating the other legs with a needle, for probably the exit was made more difficult because the earth pellet to which the egg was attached had broken away from the wall of the egg-chamber."

But the crickets after passing through the delicate

baby stage do not remain in the egg cavern, but move on to the cricket home and "playground" which consists of a series of tunnels arranged so as to cut out blocks of sand. (Plate 9, Fig. 6.) We have watched the crickets scampering round the passages after remaining quietly beside the nest for a little time. We have found these nests under pots resting on the ground, or under damp boards, etc.

ORDER ORTHOPTERA



LACE WING GROUP.

Key given by Dr. R. J. Tillyard.

Key to distinguish the Five Orders Odonata, Plectoptera, Neuroptera, Trichoptera and Lepidoptera.

1 — Metamorphosis incomplete, wings with a network of veins 2

1 — Metamorphosis complete, no network of veins on wings (except in some of the Neuroptera) 3

2 — Wings equal in size or nearly so; quite hairless .. **Odonata** or Dragonflies

2 — Wings very unequal, the hind ones much reduced; two winged stages, of which the first or sub-imago has wings with numerous minute hairs, the second or imago, hairless wings .. ..

Plectoptera or Mayflies

3 — Larva with mandibles and maxillæ forming a pair of sucking tubes; imago with complete mandibulate mouth-parts .. **Neuroptera** or Lace Wings

3 — Larva a caterpillar; mouth parts of imago not mandibulate 4

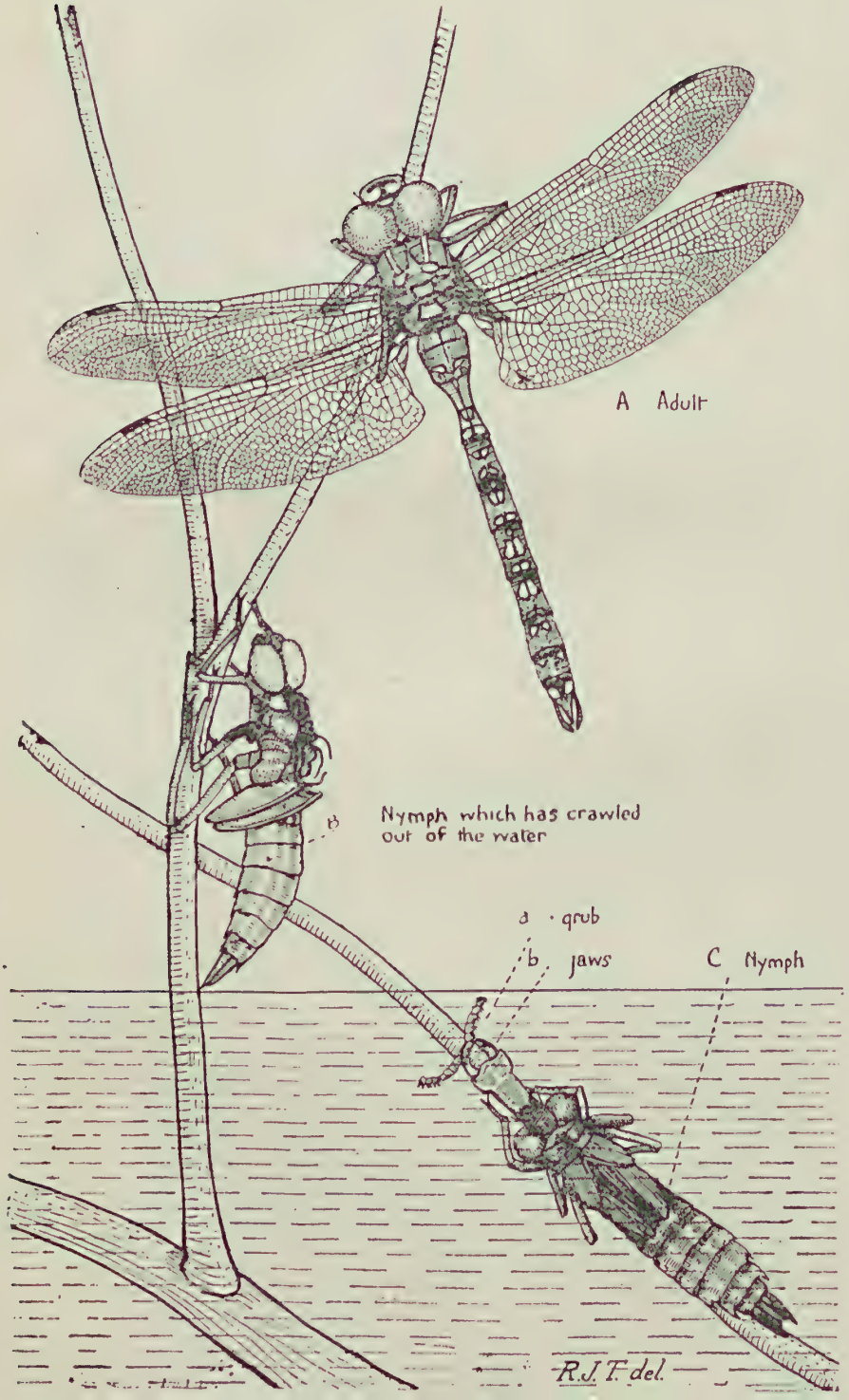
Larva aquatic, without prolegs; imago with aborted mouth-parts, only the palps remaining; usually very hairy wings .. **Trichoptera** or Caddis-flies

4

Larva usually terrestrial with prolegs; imago with a suckingtube formed from maxillæ; mandibles absent; wings with scales .. .. ..

Lepidoptera or Butterflies and Moths

PLATE 10.


A Adult
B
Nymph which has crawled out of the water
a grub
b jaws
C Nymph
R.J.F. del.

ORDER ODONATA.

(Dragon-flies.)

This group of insects, which was formerly placed in the Order Neuroptera on account of the beautiful netted-veined wings, is now placed in a separate Order—**Odonata.**

Dragon-flies are known by different names in different countries. In England and Australia they are called "horse stingers," unfortunately, though they neither sting nor bite. People will tell one in the country districts of the pain inflicted on man and beast by these "stingers."

Dragon-flies may be broadly divided into 2 groups:—

A. **Anisoptera,** the thicker-bodied dragon-flies with unequal wings.

B. **Zygoptera,** small slender dragon-flies called demoiselles or damsel-flies, with equal wings. In the former, the wings when in repose are held horizontally, and the larvæ are without external gill plates, but have a rectal chamber at the end of the abdomen, whose walls carry gills.

In the Zygoptera, the wings are held vertically over the back and the larvæ have three caudal (tail) gill plates. (Plate 11, Fig. 1, a.)

The metamorphosis is incomplete.

Dragon-flies are insect-feeders and destroy large

numbers of mosquitoes, flies, etc., so that they can be regarded as friends to man even though they incidentally may destroy some useful types. Dr. Tillyard in "Biology of Dragon-flies," makes the following observations on a dragon fly which he saw "flying round and round a small bush about 7 p.m., when the mosquitoes were particularly troublesome. After ten minutes it was captured. I found its mouth so full of mosquitoes that it was unable to shut it. There must have been over a hundred mosquitoes all tightly packed into a black mass."

The head of the dragon-fly (Plate 10) is large and very mobile; the greater part is made up of two large compound eyes, capable of a wide vision. The eyes may meet on the top of the head, especially in the males of certain species, such as *Anax* and other larger types. However, there is an exception in the large mountain dragon-fly, *Petalura*, where the eyes are not very large, and are quite separated. The eyes of the Zygoptera or damsel-flies are much smaller and more or less stalked.

The mouth is a biting and chewing type, and the jaws are very powerful, but the arrangement of the mouth parts is such that a dragon-fly cannot bite one's finger in handling it.

The wings are beautifully netted, the fore-wings being slightly smaller than the hind pair. The stronger dragon-flies are capable of very rapid flight and the wing-structure is interesting, for there is an area of strength which bears the main pressure

Fig 1. Nymph of Damsel-fly
(Austrolestes leda)
a Gill plates

Fig 2 Jaw of Dragon-fly
(Anax papuensis)
a - Hinge

Fig 3 Gill plate of Damsel-fly

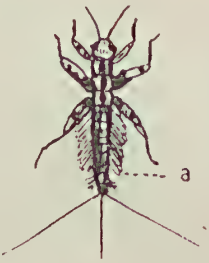


Fig 4 Larva of May-fly
(Atalophlebia)
a Gills

Fig 8 End of Air Chamber
of Dragon-fly

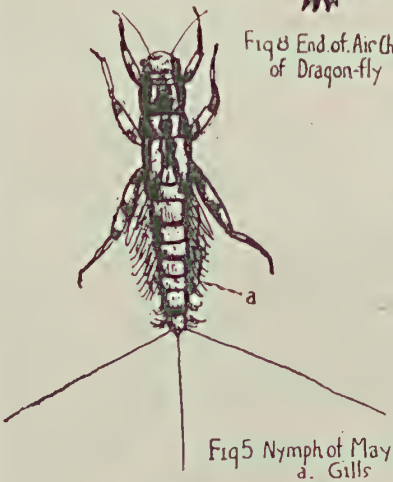


Fig 5 Nymph of May-fly
a. Gills

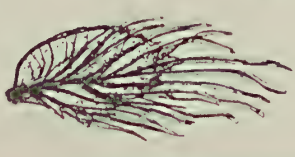


Fig 6 Gill of Larva & Nymph (magnified)

Fig 7 Adult May-fly

DRAGON-FLIES AND MAYFLIES (Enlarged).

of the air, and this part carries strong veins. The outer and lower part of the wing is softer and easily moved, acting as a "rudder," and capable of rapid vibrations. It is acknowledged that certain types of aeroplanes were built after the principle of the working of a dragon-fly's wing.

The **legs** of a dragon-fly are weak structures in comparison to the rest of the body, and from observation we know they are not used so much as a means of locomotion but mainly for clasping when at rest. The larger dragon-flies (Anisoptera) range in size from 2 to 6 inches across the wings. The colour of the body varies from a greyish-brown to a brilliant red. The more sombre tints are frequently relieved by markings of blue and green.

The **abdomen** is very elongate and narrow, and is made up of 10 segments. It terminates in a pair of anal appendages.

The eggs are laid either in reeds, or in leaves or stems of water plants—or else they are dropped into the water.

Dr. Tillyard records that of Australian dragon-flies the damsel-flies (Zygoptera) and some of the larger dragon-flies (Anisoptera) place the eggs within water weeds, while all the others just drop them into the water as they skim over its surface, and dip down every now and again, when the eggs are washed off the tip of the abdomen.

Towards the end of summer we watched with interest the egg-laying process in the species *Anax papuensis*. The male supported the female by holding her around the neck by means of the anal

claspers. Backwards and forwards they darted, one instant so close to the water as to allow the tip of the abdomen to touch it; up into the air for a few feet, then back again, brushing the water once more. This was kept up for over half an hour when finally the pair flew off.

The larva, which lives in water, mud, etc., is a queer looking little creature, possessing a robust body and three pairs of legs. (Plate 10.) The most striking feature about it is the lower lip (Plate 11, Fig. 2), which can be thrust out almost half an inch beyond the front of the head. This lip is concave and divided at the outer end into two blades. In shape it varies with the species. By means of it the unwary pond insects are grasped and pulled into the mouth; when not in use it can be folded most innocently over the front of the face, thus disguising its true use. It is thus termed the "mask."

The food of the larva consists of anything in the form of animal life which it can seize. Mosquito larvæ are apparently much relished. When the ordinary food supply fails, cannibalistic habits are developed, and then the strongest or most cunning alone survive.

We have watched dragon-fly nymphs in a fish tank made from a lolly jar about 9 inches in diameter, with water weeds growing to keep the water fresh. The plants give off oxygen which is necessary both for plant and animal life. Carbonic acid gas (CO_2) is given out by (a) breathing of plants, (b) breathing of animals, (c) decay of plants. But

CO_2 is necessary for plants, which absorb it from the water to build up, with other elements, in the water, food to enable the plant to perform its functions and build up tissues. Hence a circulation of these necessary gases is kept up and so the water in the tank is kept pure.

We observed in one of these jars a dragon-fly nymph which had just moulted, and had on its new delicate-looking pale-green skin. As we watched, another sturdy looking nymph began to stalk its pale brother. It crept slowly up, having little rests now and again, and finally seized its victim by the middle of the back. These larvæ are very voracious, and will devour with relish their smaller brothers, the nymphs of the damsel-flies and also mosquito larvæ. In collecting them we once put a nymph of a large dragon-fly with three may-fly larvæ, and a couple of damsel-fly nymphs in a test tube—a few hours later there was only one living occupant of the tube—the large dragon-fly nymph. In most cases, the nymphs of dragon-flies usually show, to a certain degree, protective colouration, their colour blending with their surroundings so that they can more easily seize their prey; for these creatures do not hunt and chase their victims, but wait for them or slowly stalk them.

The nymphs and larvæ of the larger dragon-flies have a rectal chamber at the end of the abdomen (Plate 11, Fig. 8), the walls of which carry gills which contain numerous air tubes or tracheæ. Water is taken into this rectal chamber, the air is abstracted

and then the water is shot out again. This movement of the water aids in propelling the insect forward in the water. If a nymph be placed in a dish with water to which a little fine sand has been added, the movement of the water may be seen.

The larvæ and nymphs of the damsel-flies have the gills externally placed, in the form of three plate-like appendages to the tip of the abdomen, and these gills are supplied with air tubes.

By dragging a pond with a net, they can easily be captured. These might be placed in a glass jar, in which water plants are growing, and then if supplied with mosquito wrigglers, their development can be readily noted. A piece of wood, or a rock rising above the surface of the water should also be placed in the jar, and finally a piece of mosquito net tied over the top. We found larvæ in numbers on the roots of the water hyacinth. Taking just a single root of the plant, and shaking it in a bowl of water, quite a number of larvæ were soon seen swimming around. They have evidently found out that numerous small insects live among these roots, hence the food supply is plentiful.

The larva undergoes from 12 to 15 moults in growing up. Just before the final moult it becomes listless and seems somewhat tired of its aquatic existence. It crawls up out of the water, grasping the stem of a water plant or any firm object that is near. We have known these larvæ to crawl some yards from the pond before finally attaching themselves. A short rest is indulged in, then the

skin bursts down the back, and out from the opening the head and front legs of the dragon-fly are pushed. The legs are thrown back as if to allow them to harden by exposure to the air. Then they are bent forward, and the stick immediately above the old skin is grasped, and by this means the remainder of the body is pulled forth. The creature in its new dress appears wet, limp and exhausted. The wings are represented by tiny wing pads scarcely more than ¼ inch in length. In less than one hour their wings reach their full extent, becoming firm and hard. The beautiful full-grown dragon-fly then soars away in search of food. This consists of other insects which are captured as it flies through the air.

It is well to keep the last nymph skin of the dragon-fly, for if taken when still soft, and pinned on to a piece of cork, the great mask or under lip can be drawn out and observed well. The skin then dries, and the specimen can be kept for future use.

We found a couple of shells in a cave at Clarence Siding, Blue Mountains. The nymph had crawled out of a small pool in the floor of the cave.

As a rule, the large dragon-flies are solitary insects, but an instance came under our notice where they appeared in great numbers. At this particular time mosquitoes were very numerous, but when the dragon-flies came along, for a few days, there was a noticeable decrease in their numbers.

On one occasion, when quite close to some swampy country at Long Bay, we found ourselves

surrounded by flying ants. Before many minutes had passed, scores of dragon-flies began their aerial attack. They reminded us of a flight of airships making war. The battle was short, for the fight was unequal, and then little or nothing remained to tell of the former existence of the ants.

The small, slender-bodied dragon-flies (Zygoptera) differ from the larger type in a few essentials. The hind wings are not larger than the front pair, the eyes are smaller, and stand out like beads from the head, the eggs are deposited in the tissue of water plants; when at rest the wings as a rule are held above the body of the insect and at right angles to it. These are gregarious, being found in great numbers on reeds, etc., near ponds.

A pretty, delicate-looking damsel-fly (*Austrolestes leda*) is one of the most common; another is *Austrolestes analis*. These measure about 1¾ to 2 inches across the wings. The general colour is brown with blue or pink markings on the abodmen.

When egg-laying, the female of *Austrolestes* makes slits, following a zigzag pattern in the stem or leaf of a water plant. The abdomen is curved round in inserting the eggs. The male may aid the female in the process of laying the eggs by holding her round the neck by means of tail pieces or anal claspers.

It has been observed that sometimes the male and female dragon-fly go down into the water for a few inches when heavy rains have flooded ponds. Whether it is usual, or whether it is in order to be sure to have the eggs within normal water-

height, is not certain. To obtain air in this journey they fold the wings back and air is enclosed; for one can see the silvery gleam of the air as the insects are in the water. The larva is longer than that of the large dragon-fly. The abdomen terminates in three external gills or breathing plates lined with treacheæ or air tubes.

We watched the nymph of one of these dragon-flies crawl out of the water and prepare to emerge. It pressed its body up towards the head and formed a kind of hump of its head and thorax—the nymph skin split and the adult emerged. The growth of the abdomen was most rapid. In 15 minutes it grew half an inch, and in 35 minutes it was three-quarters of an inch long.

The body of the adult or imago remained a pale green for some hours, then this colour gradually gave place to a dark brownish-green with transverse markings of pale pink on the abdomen.

ORDER PLECTOPTERA.

(May-Flies.)

These are delicate little insects with beautiful lace-wings. (Plate 11, Fig. 7.) The hind pair is usually much smaller than the fore pair, and in some species is absent. The mouth parts are rudimentary. There are three long thread-like tails at the end of the abdomen.

The life of the may-fly is very short. Reaumur considers that in some species the adult emerges at dusk and never sees the sun—living but for a few hours. However some species are said to live three or four days.

The larvæ of these insects are aquatic and are well known by those interested in water animals and insects. The habits and life histories of Australian may-flies are not well-known yet, and we will give a brief outline of the life as recorded elsewhere. The eggs are laid in water—usually just dropped by the mother, and left to drift in the stream. In another case the mother creeps down into the water and lays her eggs under stones, etc.

The larva emerges and is fitted for a life in the water, for plate-like gills are gradually developed. These gills may be fringed or may be simply plate-like. In most larvæ there are long caudal setae or

tails which are fringed, and these are regarded as special respiratory organs.

The life of the larva is thought to be very long, extending over years in some species.

An interesting feature is a stage called the **sub-imago.** When the last larval skin is shed there emerges a winged may-fly, but with dull, opaque wings, with numerous minute hairs, and differing from the true imago—hence it is called the *sub-imago.* Later this enveloping coat is shed and the imago emerges, which has beautiful transparent wings. May-fly larvæ can be found in pools and running streams. On lifting stones in the bed of shallow creeks the larvæ can usually be found in all stages of development up to the large nymphs with prominent wing-pads. (Plate 11, Figs. 4 and 5.)

The lateral gills are very interesting as they move with a motion suggestive of the movement of a silken flag in a gentle breeze.

On examining the gill with the aid of the microscope it can be seen with the main tracheæ prolonged to form a distinct fringe at the apex and outer side. (Plate 11, Fig. 6.)

A common species found in our creeks, is *Atalophlebia australasica.*

ORDER NEUROPTERA.

In this Order were included a number of insects such as Dragon-flies, May-flies, Caddis-flies, Lace Wings, Stone-flies, Ant Lions, Water Bag Moths. These have been separated into different Orders (see Key at beginning of Order Odonata.)

Order Neuroptera.

(Lace Wings and Ant Lions.)

Families—(1) **Chrysopidæ** (Green Lace Wings).
(2) **Hemerobiidæ** (Brown Lace Wings).
(3) **Myrmeleontidæ** (Ant Lions).

The venations of the wings of the insects of these three families are very widely different.

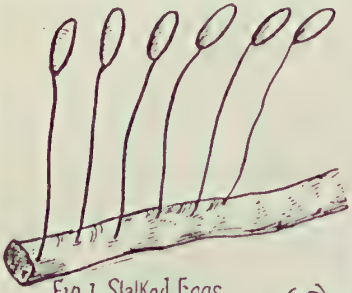


Fig 1 Stalked Eggs

Fig 2 Tiny Larva on Egg shell.

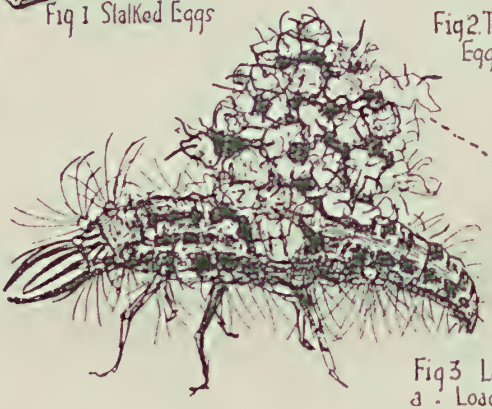


Fig 3 Larva -
a - Load of skins

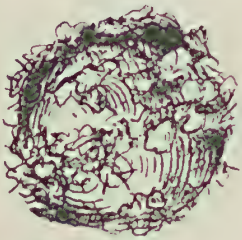


Fig 4 Cocoon.

Fig 6 Larva "Loading up"

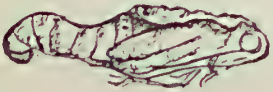


Fig 5. Pupal shell

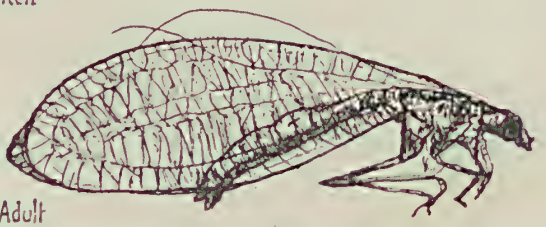


Fig 7. Adult

LACE WINGS (all enlarged).

FAMILY—LACE WINGS.

(Family Chrysopidæ.)

These pretty, delicate-looking little members of the Neuroptera have just claim to their popular name. The wings are transparent, and more closely veined than the finest net. The lace wings are recognised by a few outstanding features. The larva is provided with a pair of sucking jaws, which project beyond the head. The pupa is enclosed in a cocoon. Metamorphosis is great and complete. The larva and perfect insect may be found on plants where aphides are abundant. The adult is frequently found around the light at night time.

One of the best known is a pretty green creature, familiarly known as "golden eye" (*Chrysopa signata*). This measures over an inch across the outstretched wings, and the head is adorned with a pair of bright, jewel like eyes. The eggs are small, oval, creamish-looking bodies, each of which is deposited at the end of a rather long thread-like stalk (Plate 12, Fig. 1), such stalk as a rule being attached to or near the plant on which the food of the larvæ is found.

In captivity a green lace wing fastened about twenty of these stalked eggs to the inside of a glass jar.

The larva (Plate 12, Fig. 3), at first tiny, grows to

about ¾in. long; the general colour is green mottled with brown, and the body is covered sparsely with short hairs. It possesses huge sucking jaws, and moves rapidly by means of its three pairs of legs.

Recently we observed these larvæ on the under surface of radish leaves, which happened to be literally covered with aphides. Backwards and forwards the tiny creatures sped, and just sucked the contents of the aphides, leaving only the skins. These skins in some cases were thrown back on the body in order to disguise the larva. When aphides or scale insects are scarce, small caterpillars or grubs become good substitutes; failing these, they become cannibals, and devour their brothers who do not happen to be quick enough to evade their jaws. It is full grown in about three weeks, but this time varies according to the food supply.

The larva spins a delicate spherical cocoon (Plate 12, Fig. 4), which it attaches to a leaf or twig. This cocoon looks like a tiny soft cotton ball. It is not more than ¼ inch long, and is small in comparison to the size of the larva or of the adult. On top of the cocoon is a tiny lid, which is lifted when the adult "golden eye" pushes its head forth. About 14 days are passed in the pupal stage; thus the period from egg to full grown insect varies from 4 to 5 weeks.

The green lace wing (Plate 12, Fig. 7) has a very close relative in the "brown lace wing," which closely resembles it, but is brown and somewhat smaller.

The "painted lace wing" (*Psychopsis*) is met

with in the Western districts of New South Wales, and also around Sydney, and the young student, on account of its broad, prettily marked wings is inclined to think it a moth. The lace wings may be looked upon as among the best insect friends that the orchardist and the man on the land possess.

Observations on a Lace Wing Larva.

We placed a larva of a lace wing in a box with leaves and shoots on which were numerous aphides, and had an interesting experience watching its method of seizing its victims, demolishing them, and hoisting many of the skins on its back.

Next day we placed the larva in a box with leaves on which were aphides. After devouring them all, it wandered round the box. On some of the leaves were patches of white floccose material left by the larvæ of a little brown fulgorid insect (Order Hemiptera). The larva of the lace wing was very active, and probably hungry; it roamed round the box and at last sighted the white patch of fulgorid-threads. We were much amused at its antics. It at once set to work on this cottony-looking material, pulling it out with its long arm-like jaws, and then curving its body round in a semi-circle, its rather long legs—at least the two hind pairs—fully extended, as it stretched its head right upwards to push in the white floccose material among the aphid skins on its back. (Plate 12, Fig. 6.)

Seen through the lens as it was thus working, it looked at times like a performer at a circus, with its high light load of aphid skins, its head stretched

back and its body curved up, and the back legs taut. In most cases it pushed off the white threads as it poked them upwards among the aphid skins, but on other occasions it was not successful, and brought back small patches of the material on its arm-like jaws, but this did not seem to trouble it, for it resumed its work of pulling out more stuff and hoisting it. This continued for about three-quarters of an hour—with little rests in between—when it went for a stroll, and then came back to resume its loading up.

It pupated, forming a little round cocoon about the size of a very small pea—made of skins of aphides—fulgorid-threads and silken threads with which it wove the cocoon. The adult emerged three weeks later, and outside the cocoon was the pupal shell. (Plate 12, Fig. 5.)

Edward Step thus describes the egg laying of the Lace Wing: "When about to lay eggs, the tip of her hind-body is brought into contact with a leaf or shoot she has selected, and a minute globule of gum is attached. Then elevating her body to the full extent possible the gum is drawn out to a thread of gossamer, which hardens on exposure to air and becomes stiff enough to support the egg, which she attaches to its extremity. In so doing she is doubtless taking precautions against her eggs being eaten by some other insect, or it may be against the grubs of her own kind, for they are all of a voracious character and are not free from the imputation of cannibalism.

It has been noticed that where the eggs are

sufficiently close together the first-hatched grub will cling to its egg shell and watch for the emergence of its brothers and sisters, catching and eating them as they appear. In the ordinary way the grub crawls down the hair-like stalk of the egg and finds itself quite close to a flock of the green fly or aphis."

FAMILY MYRMELEONTIDÆ.

(Ant Lions.)

In this family, it is the larva that has earned the name of ant lion, from the fact that its food consists chiefly of ants, though from observation we have concluded that caterpillars and flies are also eaten.

To beginners the adult ant lion might be taken for a kind of dragon-fly, but the abdomen is much shorter and the body less strongly built than, at least, the stronger dragon-flies. The flight, too, is more awkward and slow—there is often a heaviness about the flight of ant lions, such as *Glenoleon pulchellus* that is very characteristic.

The wings are gauzy and beautiful—they may be clear and with a metallic sheen, as in *Myrmeleon uniseriatus*, or they may be blotched as in *Glenleon pulchellus* (Plate 13, Fig. 2).

The antennæ are fairly long, and often end in a club or distinct rounded knob.

The larva (Plate 13, Fig. 3) is predaceous, lying in wait for its prey in the sand. Some species make pits in the sand, and lie in wait at the bottom (Plate 13, Figs. 5 and 6), while other species make no pits but lie in wait in the sand. Dr. R. J. Tillyard records "that out of 600 reared, four species were pit formers, the other eight species being non-pit formers or predaceous wanderers in sand debris, etc."

The jaws of the larva are modified to form two sucking tubes in the form of two large jaws, each consisting of a broad upper piece and of a lower narrow blade which slides along the upper part, and forms a tube.

The pupa is elongate and is folded round in a beautiful little marble-shaped cocoon of sand grains cemented together by a secretion from the larva. (Plate 13, Fig. 4).

The pit formers recorded by Dr. R. J. Tillyard are: *Myrmeleon uniseriatus*, M. *pictifrons*, *Callistoleon illustris*, C. *erythrocephalum*.

Life Story of the Ant Lion.

(*Myrmeleon uniseriatus.*)

The larva, which is predaceous, makes a pit in the sand. We obtained many of these larvæ along sandy paths or bush tracks, and in shallow, sandy patches on rocky outcrops.

The larva is rather an unattractive creature, sand coloured, with a pair of large protruding jaws. The body is somewhat thick, tapering to the tail, and clothed with hairs scattered over the body. Several larvæ were obtained in November. We put them into a bowl containing sand. No. 1 made a circle and went round and round, moving backwards and forwards until it gradually came to the centre, and then it disappeared in the sand. After waiting for a few minutes we were rewarded by seeing particles of sand being thrown up. This it did by sharp jerks upwards and sideways with its spade-like head. It worked just beneath the surface of the sand, its

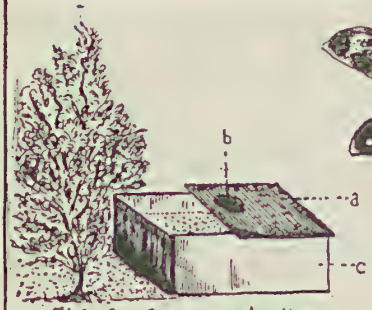


Fig 1. Box for rearing Ant lions
a. Glass.
b. Sugar.
c. Box with sand.

Fig 2. Adult (Glenoleon pulchellus)

Fig 3 Larva

Fig 5. Pits in sand.

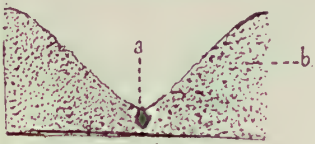


Fig 6 Section of pit
a. Larva.
b. Sand.

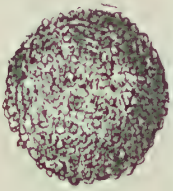


Fig 4. Cocoon.

Life History of Ant Lion

Fig 7. Caddis in Tube
a Base of Tube

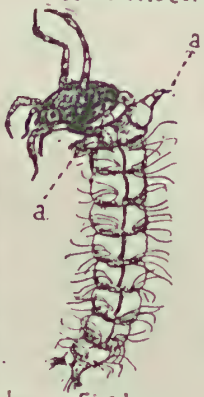


Fig 8 Larva
a Spine

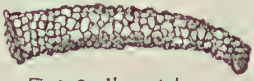


Fig 9. Sandhorn tube

Fig 10 End of Sand tube

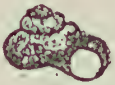


Fig 11. Shell tube.

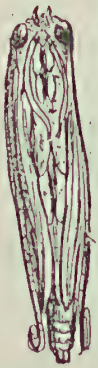


Fig 12 Pupa.

ANT LIONS AND CADDIS-FLIES (all enlarged).

free progress being aided by the shape of its body. At last it had formed a funnel shaped hole 2½ inches wide, and 1½ inches deep.

No. 2 did not make a circle, but simply backed underground and made a pit similar to that of No. 1.

No. 3 at once went underground, but did not make a pit that evening. By the morning the funnel-shaped pit was there.

Each little trapper was ready lying in wait at the bottom of its pit with only its head and jaws above the sand, or more usually with nothing showing at all.

Its jaws are wonderfully made to suit its habits. The typical biting and chewing jaws of the caterpillar are modified to form a pair of long curved jaws, with mandibles and maxillæ combining to form a pair of sucking-tubes. These jaws seize the prey, and suck up the juices from the body of the victim.

For a few days we captured ants and fed them, but later on placed the bowl outside near a vine frequented by ants. A piece of glass was put on the top of the bowl in such a way as to allow the ants to enter, and yet to protect the larvæ from the rain. Moist sugar was placed on the top of the glass to attract the ants. They came in hundreds, often forming a black mass over the glass. Many ran down over the sand. The ant lion larvæ thus got a good food supply. It was wonderfully interesting to note how these larvæ held their victims, and thrashed and jerked them about until they were exhausted, for efforts of defence on the part of the

victims were made useless by their captors, who held the prey out of reach of any vital part. At other times the ants were just pulled right under the sand. Should an ant escape, and try to crawl out of the pit, it was rather a comical sight to see the cunning little larva throw showers of sand at it till it tumbled back. Sometimes ants did escape, and often these showed a strange fascination for the pit. We noted one that had escaped, run excitedly to the edge of the pit, run around it, then backwards and forwards, waving its antennæ excitedly, and at last it departed.

The length of the larval state depends on the food supply. Plenty of food means a short larval period. It can exist without food for very long periods, probably because of the precarious method of obtaining it.

At last one pupated and formed a beautiful round cocoon, the size of a small marble, which was made from a gummy liquid silk secreted in the tip of the abdomen. This caused the grains of sand to adhere, and thus the little ball was formed. The pupal stage lasts from four to ten weeks.

On 21st February we happened to look at the bowl which had been placed in a box, and saw the sand moving. We watched for a little while, then drew the sand aside, and exposed the top of the pupal cocoon. Waiting for about 15 minutes, we saw the little trap door or lid gradually open, and slowly and carefully the adult ant lion arose enclosed in what looked like a delicate membrane, which gave it the appearance of a ghost as it

mysteriously extended itself. It remained in this position for a few minutes, then the pupal skin slit from the head downwards. The insect gradually freed itself, and proceeded to blow out its beautiful iridescent wings.

The flight of the ant lion is not graceful and quick like that of the dragon-fly, but slow and heavy —hence it is easily captured. It often rests under rocky ledges, its colouring affording it protection.

We observed on other occasions that on placing very tiny red ants into the pit, the ant lion larvæ simply tossed them out without deigning to hurt them, whereas when a "greenhead" was put in immediately after, it was seized and devoured. After a plentiful supply of ants (by means of the plan described above), there were shrivelled skins of the victims on the surface of the sand—they had been thrown out of the pit by the larvæ.

We experimented by placing a cherry stone in three pits, and had great fun watching the efforts of the larvæ to dislodge them.

No. 1, after heaving the stone up several times, at last managed to throw it right out of the pit.

No. 2, after several tries, gave it up, and just altered its home, making the best of unavoidable circumstances. It made a new base to the pit, so that the stone was to the side, and the bottom of the pit was irregular, one half being beautifully curved in the form of a semicircle, the other half, distorted by the stone.

No. 3 could not manage to remove it, so just disappeared. Next morning, however, the cherry

stone was out of the pit, so it had probably had another try, when fresh after a night's repose.

The larvæ can be watched by placing them in a box in which sand is present. A piece of glass can then be placed on the box, covering the greater part of it. Sugar is then put on the glass. (Plate 13, Fig. 1.)

ORDER TRICHCOPTERA.

(Caddis-Flies.)

The adult caddis-fly resembles a small moth, but it has wings with hairs instead of scales. The wings meet at an angle over the back, resembling a little roof.

The eggs are deposited usually in jelly-like masses on the surface of ponds. Last summer we noticed scores of globular masses of eggs floating about on the surface of the water for a few weeks. They gradually disappeared in the water, or fell into the hands of enemies.

The larva (Plate 13, Fig. 8) is somewhat like a caterpillar. It builds a permanent home for itself of sand grains, tiny pieces of stick, etc., cementing the particles together with material from its own body. In this tiny house, which as a rule, is not more than an inch long, it lives and drags it along with it as it moves about in the water. When moving in the water the head and 3 pairs of legs are extruded, the rest of the body being in the case.

The Genus *Helicopsyche* builds a little home in the form of a tiny snail shell, and as it moves about it carries it on the end of its body. The shell-like portable house is made of tiny pieces of sand cemented together. (Plate 13, Fig. 11.)

Another Genus *Hydropsyche*, whose larvæ are

thought to be carnivorous, and the larvæ of some species are proven to be so, live in shelters made of groups of tiny stones, sand grains, etc. Sharp says: "They live in fixed abodes; these are less tubular than is the rule with the portable cases, and are formed from pieces of sand and stones spun together and fixed to larger stones under water. Sometimes several larvæ live together in loosely compacted structures of this kind, and only form true cases when about to undergo their metamorphoses. Muller describes a Brazilian species as forming a case in which "the mouth-end has a large, funnel-shaped verandah, covered by a beautiful silken net. This larva lives in the rapids of various rivulets, and the entrance to the verandah is invariably directed towards the upper part of the rivulet, so as to intercept any edible material brought down by the water. Other members of the Hydropsychides form tubes or covered ways of silk, earth and mud attached to stones, and in which they can move about freely. A species of the genus *Hydropsyche* has been found by Howard to help itself in the task of procuring food by spreading a net in the water in connection with the mouth of its case. This net is woven in wide meshes with extremely strong silk and supported at the sides and top by bits of twigs and small portions of the stems of water plants. Small larvæ brought down by the current are arrested by this net for the advantage of the larva which lurks in the tube."

Caddis worms are found in still water, running streams, and in damp mossy situations, according

to the species. The *Helicopsyche* are found only in running streams. The larvæ of caddis-flies are chiefly vegetable feeders or have a mixed diet, while some are carnivorous. The larval stage is said to cover several months, but this varies with climate and species of larva. It is thought that in the tube-caddis, there is circulation of water through the tube even when the back of the tube is partly blocked up. On pupation the larva spins a silken net at each end of its case, and provides for the circulation of water.

The larva is said to attach itself to the tube by means of a pair of appendages at the end of the abdomen, and this is thought to be aided by a pair of projections from one of the body segments.

One of the common caddis worms (a Sericostomatid) builds a little cylindrical case which is broader at one end. (Plate 13, Fig. 9.) On examining with a lens, the sand grains which were translucent, were seen to be beautifully cemented; the average grains were uniform in size, with smaller ones fitting into smaller spaces between the larger grains. On examining one of these cases we found that the broader end seemed to be completely closed in by a "door" made of three large central grains with an outer circular row of smaller ones. (Plate 13, Fig. 10.) The narrower end was darker in colour and was partly closed with a particle of plant tissue. Within this brittle case was a perfect pupa, showing wing pads and long antennæ. (Plate 13, Fig. 12.) One of the common genera found about Sydney in pools

is *Notonatolica*; another *Helicopsyche*, which makes a snail shell tube into which it retires on resting, and this species is only found in running streams. Another is *Hydropsyche*, which lives in a home made of a few pieces of gravel, etc., grouped together on rocks.

Observations on the Larvæ of Caddis-flies.

(*Notonatolica.*)

We obtained some larvæ of caddis flies from a stream in a gully at Thornleigh, in May. We brought them home and also some sand and water weed (*Callitriche*) and placed them in a glass bowl, and spent some very enjoyable hours watching them. At night we put the bowl out in the garden near some cannas, and each morning brought it in and placed it in the sunshine. The larvæ which were resting when first brought in, soon became lively as the warm sunshine played on the bowl, and set to work in a very business-like way to get breakfast.

The cases were about half an inch to one inch in length (according to the age of the larva.) Each case (Plate 13, Fig. 7) was narrower at one end, for as the larva develops it increases the size of the case. It was made of little scraps of stems, leaves, etc., cemented with interwoven threads to form a complete bag-like canal, for, at the posterior end was a clear piece of woven material with a little circular hole in the centre; there were only a few "scraps" sewn in on the edge. (Plate 13, Fig. 7a.) This would allow of circulation of water through

the case and for the exit of excreta. One larva had chosen a piece of a hollow rectangular stem about ¾ inch long, and had covered the ends with a membrane-like material, with a few pieces of stem and other material woven in, and at the posterior end was the little circular hole before mentioned.

The larvæ seemed to feed on microscopic growths on the stems and leaves of the water plants, for they continually passed along the water weeds not gnawing off pieces, but just bruising the delicate leaves of the plant, for with the lens one could see little bruised places on the leaves, while the stems were unaffected.

The legs and the way the larvæ use them are rather interesting. The three pairs are all of different sizes. The hind pair is very long and when floating on its back near the surface of the water as the larvæ frequently did, these legs were gently moved like oars. Also in climbing upwards along a stem, they were first placed forward to get a reach, and then the smaller pairs were brought into play, and the body pulled forward. The front pair is the shortest, and as the creature moves quickly forward one can see how the marked difference in length is rather a help than hindrance, for the hind pair takes a good long reach, the next pair a lesser reach, and the front pair just an ordinary step. One could observe this well, for these larvæ had a habit of moving along on their backs, both in swimming and in walking along plants, but they could quickly turn themselves round again. They rested frequently from the labour

of feeding, and would then retire into the case extending a pair of legs to take hold of a stem; the position varied, at one time one would hold on to a stem and the body and case would be vertical, giving it the appearance of standing on its head; or it might hold the case at an angle. Sometimes one would get under a leaf or stem and rest there without even the exertion of holding on. The head and legs are partly withdrawn, the ends of the long hind legs curved round the head which was seen under the flap of the case. The creature just looked like a person in a closed-in hammock, lying back with arms at the back of the head and viewing the world—too lazy to move even a leg. (Plate 13, Fig. 7.)

When stretching to reach some object the larva withdrew part of the protected body which is quite white and with a number of long white hairs, which curved round the body, giving it the appearance of being wrapped in loose white fibres.

A curious habit they had of "grazing" over one another's cases, and as one alighted on the case of its mate, the latter would begin on his, and round and over they would go, and so quickly that they resembled a pair of playful puppies, especially as one would get tired and jerk its mate off. We examined the case under the microscope and found that numerous green water algae were growing on it, and this is what the caddis grubs were seeking.

We examined a larva out of its case (Plate 13, Fig. 8), and found that there were three projections on the first segment of the abdomen. One at the

back which projected outwards like a spine, and two lateral ones, much shorter. (Plate 13, Fig. 8a). There were a pair of suckers at the end of the abdomen. These processes probably enable the larva to maintain its position in the case and by adpressing the projections, it could slip smoothly within the case.

There is a group of Caddis flies belonging to the Family *Hydroptidae*. These are minute caddis flies, and the larva which we observed was practically microscopic. The case was transparent and brownish fawn, and we watched the larva feeding on water plants, such as delicate algæ.

An interesting note on water insects was given by Mr. F. W. Carpenter, M.A., in "The Australian Naturalist." It describes an excursion to Heathcote in July. "Many larvæ were obtained by diligent dredging of the water weeds, and these were carefully examined alive in a shallow white dish full of water. The larvæ of the dragon fly *Austrolestes cingulatus* were found in various stages of development, and in some the budding wings were clearly visible. The fine caudal gills of this genus were pointed out. The whirligig beetle *Macrogyra*, and the back swimmer *Notonecta* (a bug), were both found on the weeds.

"The abundant fauna was discovered on the under surfaces of submerged flat rocks. The small conical cases of the caddis larva *Helicopsyche*, were seen to be built of fine sand grains, whilst the green transparent pupa of *Hydropsyche* was found hidden amongst a little mound of pebbles

firmly secured to the rock which serves as a shelter for the larva of this genus. The active larva of the mayfly *Atalophlebia* proved most interesting when examined with a lens in a bright light, the rapid rhythmic motion of its gills being specially fascinating. Several interesting dragon fly larvæ were collected, including *Austrocordulia refracta*, *Aeschna brevistyla*, *Hemigomphus heteroclitus*; the latter were obtained by careful searching of the clean sand of the creek bed, whilst the *Aeschna* larvæ were best obtained by dredging the vegetable debris.

The larger dragon-fly larvæ were put into a dish with a little fine mud amongst the water. This served to detect the current of water which is ejected from the rectum with sufficient momentum to cause the forward propulsion of the larvæ. In such cases the gills are internal, and line the walls of the rectum; they absorb the oxygen from the water before it is ejected. The more rapid the swimming movement the more abundant is the supply of oxygen for respiration. This method of propulsion was actually tried on an experimental scale for the propelling of boats, but proved inferior to the screw.

It is worth notice that in many cases the dragon-fly larvæ were in various stages of development. Thus by patient search, it was possible to see a considerable portion of the life-history without the long waiting so often necessary in the case of certain other genera where the individuals are all at the same age at a given time."

ORDER HYMENOPTERA.

(Sawflies, Ichneumons, Ants, Wasps, Bees.)

The word *"hymenoptera"* means "membranous wings." It is derived from two words, *hymen*, a membrane and *pteron*, a wing. Insects of this order have two pairs of membranous wings, which are usually transparent, and at the base of the fore-wings on the second segment of the thorax is a cup-like scale which covers the base of each of the fore wings. This scale is termed a **tegula.** (Plate 21, Figs. 9 and 10.) The veins of the wings are chiefly lengthwise, and with comparatively few cross-veins. These insects can thus be easily distinguished from a typical insect of the Order Neuroptera (lace wings), which have numerous cross-veins forming a distinct lace work. Flies (Order Diptera) also have membranous wings and in general, more nearly resemble hymenopterous insects, but flies have but two wings. The hind wings of hymenopterous insects are smaller than the front pair, and in repose often slip partly under the front wings, so that one needs care in examining some of these insects to separate the two pairs of wings. In flight the hind wings hook on to the front pair by means of a row of curved spines (Plate 14, Fig. 5) which are present on the front margin of the hind wings. On the back margin of the front

Fig 1. Mandibles of Ant

Fig 2 Mandibles of Bee

Fig 3 Ovipositor of Ichneumon

Fig 4. Saw of Sawfly

Fig 5. Hooks on Back-wing of Bee

Fig 6 Sting of Bee. a

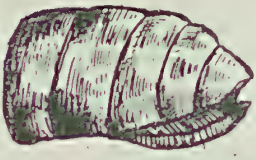


Fig 7 Abdomen of Sawfly
a - Saw

Fig 9 Sawfly

Fig 8 Cluster of Sawfly Larvae

Fig 10 Pin-tail Larva.

Fig 11 Larva of Perga. Lewisi

HYMENOPTERA (all enlarged).

wings, is a groove into which the hooks fit. The effect of this combination is to present a larger surface or "sail" to enable the insect to fly with greater power, for most hymenopterous insects have good flight. The **mouth** is modified from the typical biting-mouth of the cockroach, etc., in accordance with the habit of these insects of feeding upon the nectar of flowers. Yet it is not a purely sucking-mouth as seen in butterflies and moths. There are always **mandibles** present (see Plate 14, Figs. 1 and 2); these are used for various purposes; bees use them to cut and knead the wax for the cells of the hive; paper-nest wasps use them to tear pieces of wood with which to make the "paper" for their nests, and also to seize and tear their prey; while mud-daubers use them to work up the pellets of mud into "bricks" for their little earth-cells or rooms, and also to cut and tear the soil if they burrow in the earth. Some ants use the mandibles very effectively as weapons of defence and attack, they can piece their foe with the stout prominent mandibles (see Plate 14, Fig. 1,), and then spray the wound with poison or formic acid.

We will take the bee's mouth as a type for the Order Hymenoptera (see Plate 25, Fig. 4), though the mouths of the other insects in this group may vary more or less from this type.

If a bee is soaked in a weak solution of potash for a couple of days, and the front part of the head cut off, and examined first with a lens and then with the microscope, the following parts can be separated and noted. (See Plate 25, Fig. 4.) The

mandibles are in the form of a pair of dark stout chitinous plates or blades, just under the upper lip or labrum. The outer **chewing jaws or first maxillæ** are very much modified from those of the biting mouth. The **maxillary palpi** or palps which are long and fine jointed in the former, are here reduced to mere lobes at the base of the maxillæ; the latter, instead of being strong jaws, are elongated to form a pair of long palp-like appendages capable of free movement and clothed with hairs. The **labium** and **inner maxillæ** which in the biting-mouth are fused to form a solid central and posterior basal lip, called generally the labium, here are still fused, but the labial palpi are elongated to form much longer appendages, and the central part is elongated to form the **ligula** or tongue. The **ligula** (Plate 25, Figs. 4 and 6) is a central rod with three grooves and a rounded button-like appendage, the **bouton**, at the tip. There is a central elongate groove along this rod, and two smaller lateral side-grooves. Should only a small quantity of nectar be taken up the central groove is used, if a larger quantity the side grooves are also used. The ligula and labial palpi are clothed with hairs. Should a still larger bulk of nectar be absorbed the insect employs a very wonderful means of obtaining it. It places the long palp-like outer maxillæ side by side till the hairs of each intertwine. Then underneath these it brings the lower elongate labial palpi, in such a position as to make them fit closely against the upper maxillæ, and the hairs of the four appendages

intertwine to form a pseudo-tube. (Plate 25, Fig. 5.) In the centre of this so-formed tube the elongate ligula can be moved freely.

The **metamorphosis** of the Order Hymenoptera is **perfect or complete.** The larva in the sawflies is a grub with three or more pairs of legs and anal claspers. (Plate 14, Figs. 10 and 11.) But the typical larva is a legless grub or maggot. It differs in most cases from the dipterous or fly maggot, in that the head and thorax are bent over on to the abdomen thus being a "hooked maggot." (See Plate 16, Fig. 2.) It is usually soft and delicate because it is protected in sand homes, in mud cells, in cells of wax or paper. The larva of the saw fly, which feeds on leaves of *Eucalyptus* has a tough integument, for it is exposed and moves about freely to obtain food for itself. The pupa (Plate 16, Fig. 11) is very often enclosed in a cocoon, the appendages of the pupal body are somewhat free and not so closely adpressed to the body as is the case with the moth pupa. The cocoon varies according to whether it is exposed or protected. In mud-daubers where the cocoon is protected in the mud-cell it is very brittle, while those that are more exposed are woolly and strong.

External Features of the Adult.—The three parts of the body, the head, thorax, and abdomen, are easily distinguished. (Plate 15, Fig. 2.) The **head** is usually well separated from the thorax by a narrow neck. The thorax is stout and broad. The first or part of the first abdominal segment is added to and fused with the thorax. It is termed

the **propodeum** and is for convenience regarded as part of the thorax. Also for clearness we will regard the true second segment of the abdomen as the first, for it is the first segment of the abdomen as one sees it. The abdomen is usually stalked with a stalk or **petiole** (Plate 22, Fig. 8.a.) more or less long; this gives free movement to the abdomen which is a great advantage to those insects which sting.

At the end of the abdomen of the female is a sting, an ovipositor, or a saw. (Plate 14, Figs. 3, 4, 6 and 7). Professor Spencer in "Across Australia" thus sums up the foresight of hymenopterous insects: "The utilization of the nectar of flowers or of the sweet material secreted by other insects for the manufacture of honey, seems to be a faculty possessed only by members of the Hymenoptera among insects. Bees store it in combs, ants in the bodies of certain members of the community; and in regard to this particular point both of these insects are more sagacious than the Australian savage who literally takes 'no thought for the morrow' and never thinks of laying in a store of food to help him to tide over bad times."

Social Instincts.—Saw flies show a tendency to social habits in most species by the habit of the larvæ being clustered together in confused intercoiled groups while in repose, after feeding on the leaves of Eucalyptus. (See Plate 14, Fig. 8.) They also pupate in the ground close to each other, sometimes forming a solid mass of cocoons.

The **Mud-daubers** (Wasps) or solitary wasps

make houses of several cells or "rooms" and store food of paralysed insects in readiness for the baby-grub which will hatch out from the egg the mother wasp lays on one of the stored victims in each cell.

Mason bees also make mud homes of many cells and store honey and pollen mixed into a paste (bee bread), and the mother mason bee lays an egg in each cell and then closes it up.

Some of the **Andrenids** or short tongued bees make little homes in the earth, and the mother bees (*Andrena*, etc.) make their homes near to one another to form a little village. This is also done by some of the sand wasps of genus *Bembex*.

Another **Andrenid bee** (*Halictus*) makes a compound home common to several mothers. There is a tunnel made in the earth which is the "common entrance," and running off from this are side passages, and one mother takes charge of each side passage. This is an advance in social instincts. Each mother bee makes little cells, stores honey and pollen and then closes up the cell.

Yet another advance is made by some true wasps of the Genus *Synagris*. In some species of *Synagris* the mother builds mud cells, but instead of storing the paralysed caterpillars, laying an egg on one and then closing the cell, the mother wasp makes the cell, lays an egg, and then when she thinks it is ready to hatch she hunts for caterpillars, paralyses them, and puts them ready for the baby wasp-grub. Day by day the mother feeds her little baby with fresh caterpillars. Then when

almost ready to pupate she seals up the cell and proceeds to make a new one. Another species of *Synagris* advances still further. Instead of placing the caterpillar beside the wasp-grub, she masticates the caterpillar to form a little pellet of food-paste, and places it just below the mouth of the wasp-grub (See Plate 23, Fig. 10), just as is done by the paper nest wasp. When the larva is nearly ready to pupate the cell is sealed up.

The Vespid Wasp (See Plate 24) advances still further—the mother wasp lays the foundation of the paper nest in spring. She makes several cells and lays an egg in each, then has to feed the "babies" which hatch out. These early wasp-larvæ pupate later and emerge as worker-females, a special caste, which do not lay eggs, but help their mother to feed the baby-wasps, to make new cells, clean and enlarge old cells, etc., thus making a true social community. In the autumn males and females hatch out. The males soon die and the fertilized females hide in crevices, under stones, etc., till the spring comes, when each may found a new nest and colony. Thus all the inhabitants of the old nest die except the fertilised females which were born in the late autumn, and each wasp community only lasts for one year. The deserted nests may survive long after communities have died out.

The highest form of social development is seen by many species of ants and hive bees. The nest of a bee will last for years, while those of ants often last during the life time of a man. Their social

habits are very much advanced, the care of the home and the general good of the community being the main features.

Classification of the Order Hymenoptera.

This order is divided into two main groups. The first embracing comparatively few species, the second group including the vast bulk of the families and species of Hymenoptera.

I. Group **Sessiliventres.**—This term means "stalkless bodies," and includes sawflies which are thick-set in appearance, for the thorax and abdomen are similar in width. The abdomen has not narrowed to form a stalk or petiole at its junction with the thorax—it is **sessile** or stalkless, *e.g.*: sawflies.

II. **Group Petiolata** (ants, wasps, bees).—The abdomen has a petiole or stalk at its junction with the thorax. This is well seen in the mud-dauber wasp (*Pelopaeus*).

This group can be again subdivided into

(1) **Parasitic** Wasps, including Chalcids, Braconids, and Ichneumons.

(2) **Fossores** (Digging Wasps), including Thynnids, Scoliids, Sphegids, Pompilids.

(3) **Diplopterids or True Wasps** (wings folded fan-wise), including Eumenids (Masons), Vespids (Paper-nest Wasps).

(4) **Heterogyna** (various females).—Ants

(5) **Anthrophila** (flower lovers).—Bees.

Group I. Sessiliventres.

Family **Tenthredinidæ** (Sawflies).—These are

vegetable feeders. The larvæ of this group are better known than the adults (Plate 14, Fig. 8). They may be seen in clusters on the leaves of *Eucalyptus,* and when disturbed, they turn up their tails and eject a greenish fluid, hence the children call them "spitfires."

The adult is a thickset insect (Plate 14, Fig. 9). Some of the more brightly coloured ones may be mistaken for the more thickset species of wasps, until the absence of the petiole is noted. The mother sawfly has a "saw," an instrument for cutting slits in leaves, situated on the underside at the end of the abdomen. (Plate 14, Figs. 4 and 7.) It is a beautiful little tool when seen with the lens, and can be placed in a slit in the abdomen, or pushed out just at will. (The saw can be seen well by gently drawing it out with a needle).

After cutting the slits in the leaves, the eggs are laid and from them hatch out grubs which differ from most hymenopterous larvæ in that they are quite capable of supporting themselves—for they can move freely about on the leaves and eat; they have strong biting jaws.

The mother sawfly of some species shows a tendency to social insects by hovering over the eggs and young larvæ, *ex.*: *Perga lewisi.* At such a time she is easily caught.

The larva of the common large sawfly *Perga dorsalis* is a grub with three pairs of strong horny legs, and a pair of anal claspers. The grubs feed on Eucalyptus leaves, and go about like flocks of sheep feeding, and scattering somewhat when doing so.

They come together during the resting and non-feeding period, when they crawl over one another and form a solid phalanx, which, when disturbed, sends up a number of tails and ejects jets of fluid, thus showing a more formidable front to the enemy (birds or parasitic wasps) than a single grub would do. The grub of *Perga lewisi* is very similar. (Plate 14, Fig. 11.)

There is another common type of sawfly whose larva has a body which is prolonged at the end to form a rat-tail (Plate 14, Fig. 10). These grubs have eight pairs of pro-legs (or pseudo-legs), and are found on *Leptospermum* bushes in groups of six or seven, but feeding separately and not in squirming masses, at least in the day time when we have seen them. This one is called the "pin-tailed sawfly" (*Pterygophorus*). Froggatt records of this larva: "When full grown it bores into dead wood pupating in a rounded oval cocoon."

In most species, the larvæ of sawflies pupate in the soil, usually in close proximity, and specimens have been found showing a solid mass of sawfly cocoons which had been made in the ground.

So we see that there is a tendency to social habits in the gathering together of the larvæ and pupæ.

Experiment.—Sawflies can be reared by placing the grubs in a box with several inches of soil, part of which is damp but not too moist. The food plant can be placed in the damp soil or in a shallow bottle with water in it. They are not easily reared

in captivity, but we have reared out *Perga* in such a box described above.

It is interesting to see the marching of a body of these larvæ along the ground in order to pupate. We watched a group of them on the Blue Mountains at Clarence. They were the larvæ of the large sawfly *Perga Cameronii*. They were passing over ground covered with the greyish-fawn dead leaves of gum trees. Numerous twigs were scattered among the leaves. For two days we watched them—a group of about twenty-five; they had assumed a greyish-fawn colour, and were travelling along quite close to and partly embracing each other, stopping every now and again to "tap tap" with their heads. Usually a couple of leaders would tap! tap!, then they would stop, and at once all would tap! tap! with their heads. When touched with a twig they hoisted up their tails. They did not move continuously but would progress in a squirming mass for a few inches and then stop. On the third day they had disappeared.

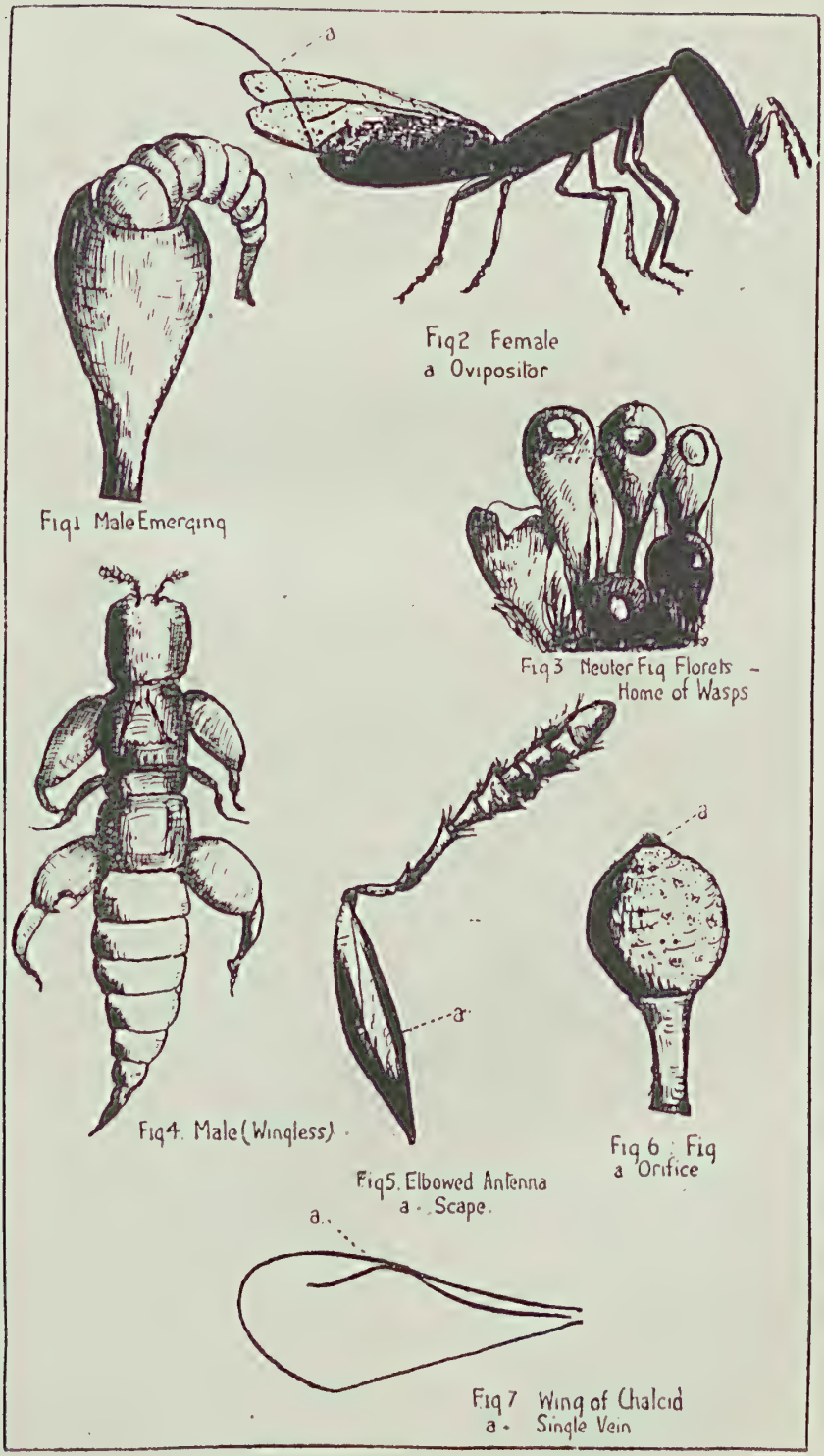
The "Pear Slug" Sawfly, *Selandria* is an introduced pest from America. The larvæ damage the foliage of cherry, pear and other trees.

Group II. Petiolata. (Abdomen with petiole or stalk.)

(1) Parasitic Wasps.

A Family Chalcidæ.

Chalcid wasps are among the most numerous of the families of the Hymenoptera, but most of them



CHALCIDS (greatly enlarged).

are so tiny that they are not popularly known. They are called the "micro-hymenoptera."

They can be distinguished from the other small wasps by the following: (a) The wing has no cell system, but a solitary vein or nervure which runs longwise with a short backward turn (Plate 15, Fig. 7); (b) the antennæ are elbowed, that is, there is a long basal joint, and a jointed upper part stands at an angle to the long, single, basal joint. (Plate 15, Fig. 5). Note the antennæ of some of the male chalcids are branched and look like tiny feathers.

Life History.—The eggs of the chalcid are laid by the mother inside the victim or host, such as a grub, caterpillar, etc. A tiny legless grub hatches out—it is white or cream, and delicate in texture, for it is protected within the body of the host, where it takes nourishment either by absorbing the liquid food, or by sucking it through the mouth. The host does not seem to be seriously inconvenienced by these self-invited guests, but just gradually weakens and dies, leaving an empty shell of the harder indigestible parts. If the chalcid is small, many eggs may be laid in the one host. The caterpillar, etc., may reach the pupal stage but does not live to become a perfect insect.

Chalcids are useful when they parasitise the larvæ of some of our pests such as the codlin moth, grape vine moth, lucerne moth, scale insects. Gall insects are also attacked by them while certain species of chalcids are said to make galls.

There is a very interesting relation between some

of the chalcids and the fruit of fig trees. In the wild figs of Asia Minor there is a kind of commensalism of the fig and fig wasp (*Blastophaga grossorum*). The fig is a hollow enlarged receptacle with a tiny opening at the apex, called the ostiole." (Plate 15, Fig. 6 a.) Within the receptacle are many tiny florets or fig flowers, male, female and neuter. The neuter florets are altered female-florets, in each of which a mother-wasp lays an egg. A tiny wasp maggot hatches out and feeds on the tissues of the neuter floret. It pupates in it, having eaten all the substance of the floret except the shell which makes a little pupal chamber (Plate 15, Fig. 3) where it changes into the adult chalcid.

The female wasps pass in and out of the figs, laying eggs in them, and in this passing from fig to fig, they carry the pollen of the male florets to the female florets which are fertilized and thus improve the quality of the figs. The common cultivated fig called the *"Ficus type"* has no male florets, and many fruit growers of Italy, Greece, and Asia Minor cut branches of the uncultivated fig, the *Caprificus* type, which have male florets present, and they hang them on the branches of the cultivated tree (*Ficus*) believing that the wasps will visit their figs and increase the growth (by carrying pollen and causing fertilization). This is called "Caprification of figs."

Certain species of edible preserving figs will only ripen well with the aid of wasps, causing fertilization, but the ordinary edible figs will ripen

without any such intervention. We had a very interesting time watching the chalcid wasps on the figs of the Port Jackson and Moreton Bay trees. For several years in the months of February and March we saw numerous wasps of species *Pleistodontes froggatti*, and two other species in fewer numbers, in these figs.

The males are usually yellow or orange in colour, wingless, and blind. (Plate 15, Figs. 1 and 4.) If some of the smaller green figs be cut across and then broken up and examined with the lens one can see the curious female and male florets, and others occupied by wasps—these we might call the neuter florets. The female florets produce the tiny fruits (seedlike). The wasps occupy their little homes, and one can see the larva, pupa, and adult, each in different little compartments, for on breaking the fig, the walls of some of the little neuter florets are torn away. Many wasps were ready to emerge and began moving the head and legs very slowly, like a tired child being wakened from sleep. They slowly pulled themselves out of the pupal chamber with a few little "rests" in between. The females seemed to be mature earlier than the males, for in the young figs we opened there were more females mature while only a few males came out; in the older figs the males were more numerous.

The females are black (Plate 15, Fig. 2), and so easily seen. They are active, winged, and have a long slender ovipositor. The males can be distinguished from them, for they are of a general deep cream colour, the head and thorax

a reddish brown, and the body which tapers to a fine point, is a creamy colour. Sometimes the females left their wings behind either in the shell of the floret, inside the fig, or after they reached the outer surface of the fig. They are quick-walking insects and can get over the surface of figs and leaves very smartly—they either walk or fly to other figs. They carry pollen on their bodies to another fig, where, in walking among the florets they lay the eggs in some of them, and at the same time dust pollen on to the female florets. The wingless males never leave the figs. On one occasion we cut open a fruit of a Moreton Bay fig tree and disturbed dozens of little metallic greenish chalcid wasps with a very long ovipositor. (*Idarnis australis*). These wasps scrambled out of their pupal homes, and as quickly as possible and one after another, they bent the ovipositor and took a flying leap out of the fig without even waiting for their wings to dry. Then they exercised their wings in the open. They reminded us of a number of children jumping off a spring-board in the baths.

Mr. Froggatt, in "Friendly Insects," thus sums up the micro-hymenoptera, to which the chalcids belong:—

"They comprise thousands of the most beautiful and often most curiously formed little creatures in the insect world; while some are rich in bright, metallic tints, others are dressed in black, with the usual prim wasp-like form. They differ from the former groups in structure of the antennæ, and in having hardly any cross or parallel veins in the

delicate gauze-like wings, while most of them are very small, and many microscopical, those of the group with extended tails reaching ¼ of an inch in length being the giants. In summer the bush, garden, orchard, and field swarms with countless thousands of the smaller forms of these parasites; nothing is too small for them to infest. One group lays its eggs in the eggs of spiders. Others insert their ovipositor through the protective covering of the mantis eggs, and discharge their eggs therein. Another black ant-like wasp infests the eggs of grasshoppers, and several curious species can be obtained from the pupæ of our large bull-dog ants.

To the farmer, however, the most interesting are those which destroy the small moth caterpillars of which there are many. The best known are the chalcid wasps, short, thick-set, hard, shining, black and yellow wasps, which have the thighs of the hind legs so thickened that, drawn down on either side of the abdomen, they are often quite as large as the short oval body. All the members of this group are parasitic on the larvæ of small moths. One attacks the codlin moth, and is known as the "jumping fly" because it has the power of springing up by contracting the swollen thighs. If any one wishes to observe these little friendly insects he has only to collect a bunch of galls of a gum tree, some insect eggs and cocoon, and place them in a closed jar, where in a few weeks he will see these little creatures crawling over the surface of the glass trying to escape.

A very curious fact is the development of some groups of these tiny parasites which has been discovered within the last few years, namely, that the ovum or egg deposited in the caterpillars swells out and divides into a number of separate eggs, each capable of producing a perfect wasp, so that each egg deposited by the parasite multiplies into many. This discovery explains the rapidity of the increase of many of these minute creatures."

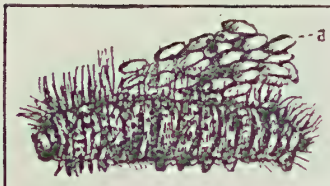


Fig1. Cocoons of Braconid Wasp on Caterpillar

Fig2 Larva of Braconid

Fig3. Cocoon of Braconid

Fig4. Open Cocoon a - Cap

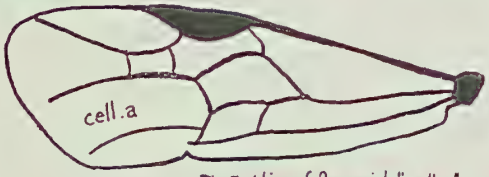


Fig.5. Wing of Braconid "cell a" undivided

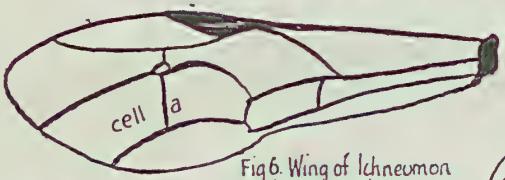


Fig6. Wing of Ichneumon "cell a" divided.

Fig7. Eye of Ichneumon

Fig9. Sucking Mouth of Ruby wasp

Fig8 Ichneumon (*Opkion*) a. Ovipositor

Fig11. Pupa of Ruby-wasp a - Excretion b. Mud cell of host.

Fig10. Ruby-wasp: One wing removed a - Spine

PARASITIC WASPS (enlarged).

GROUP II. PETIOLATA.

Parasitic Wasps.

B. Family Ichneumonidæ (Ichneumons).—These wasps can usually be distinguished from chalcids by the following characteristics: (a) larger size; (b) more numerous veins on wings; (c) the antennæ are not elbowed and have many joints. Ichneumons can be distinguished from braconids (the next group of parasitic wasps we will discuss), by the structure of the wing. Note that the second space marked "cell a" of the posterior or outer end of the wing (counting from the lower part of the wing), is divided into two smaller cells by a transverse veinlet. (See Plate 16, Fig. 6.) In the wing of braconids this second space or "cell a" is large having no transverse veinlet. (See Plate 16, Fig. 5.) The abdomen and appendages of ichneumons are usually more mobile than those of braconids. These ichneumons are very useful insects, parasitising some insect pests, for example, the acacia moth (*Teia*), cut worms such as the larvæ of bugong moth, vine moth caterpillars (*Phalaenoides*); they also attack the caterpillar of the emperor gum moth (*Antheraea*).

A common ichneumon is the genus *Ophion*. (Plate 16, Fig. 8.) It is reddish brown with a rather long petiole to the abdomen. The body is rather thickened and truncate or cut off abruptly at

the tip. The female has a long ovipositor. This suggests that it parasitises caterpillars clothed with long hair or bristles, or larvæ hidden in the wood or bark of trees, such as wood-boring grubs, etc. Note that parasitic wasps with long ovipositors usually parasitise internally, that is, they pierce the skin of the victim and lay an egg inside its body.

The genus *Pimpla* or as it is more recently called *Echthromorpha* is a very common ichneumon; it is black with red legs and antennæ, and on the thorax and abdomen are whitish yellow spots.

Rhyssa semipunctata is a reddish wasp with the base of the abdomen black with a row of white dots on each side of the body. The segments near the tip of the abdomen are red and without white dots. The ovipositor of the female is long and consists of stout bristles. This wasp is parasitic on many caterpillar pests.

One genus, *Bassus*, parasitises the larvæ of the syrphid flies, and is not therefore a friend, for the larvæ of some syrphid flies destroy aphides. The adults of these wasps feed on the nectar of flowers

Life History of an Ichneumon.

We noticed on the leaves of a wistaria plant some small white seedlike cocoons with dark patches. They were about a quarter of an inch long, and about an eighth of an inch wide.

There were also cut-worm larvæ of the moth *Plusia* feeding on the leaves of the same vine.

One morning, about 8 a.m., we noticed a small narrow cut-worm caterpillar, about an inch long, with a clear white patch at one end. On examining with

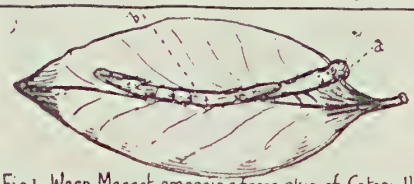


Fig 1 Wasp Maggot emerging from skin of Caterpillar
a Host b Wasp-maggot

Fig 3 Maggot getting ready to pupate
a Fastening threads

Fig 2. Same Enlarged
a. Skin of Host
b Wasp-maggot

Fig 4 Maggot Disappearing within cocoon

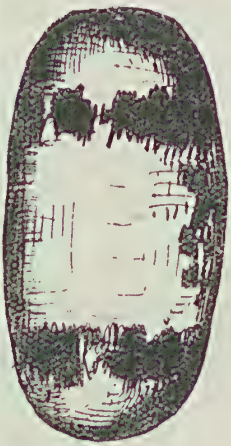


Fig 5 Completed Cocoon

Fig 6 Ichneumon wasp adult

LIFE HISTORY OF AN ICHNEUMON WASP.
(Much enlarged.)

a lens we saw that there was a tiny green maggot making its way out of the caterpillar, and the white patch was the shell of the head end of the latter, and the maggot was making its way out by the anal end of the caterpillar. (Plate 17, Fig. 2.) By turning and twisting its body in a half circle the wasp maggot extricated itself from the remains of its host. At 8.25 p.m., the maggot was quite free and crawled about a quarter of an inch away. It was now shorter and thicker. It then fastened itself at each end by a series of rope-like threads (Plate 17, Fig. 3), and gradually it began to spin itself within a cocoon of stout threads. We watched it working steadily, turning this way and that, till at 9 a.m. it could just be seen with head curved under the body and still moving it backwards and forwards. At 11 a.m. it could not be seen. There were thin patches on the cocoon where the threads were not so densely woven, and as the body of the pupa darkened the darker surface showed through the thin spots of the white cocoon, giving it its mottled appearance.

The adult ichneumon escaped by cutting a hole at the end of the cocoon. It hatched out in a fortnight; it was like a tiny Ophion ichneumon.

We noted that it was only the very young caterpillars that were parasitised. If they escaped during that stage they were not subsequently attacked; for on capturing a dozen larger larvæ and keeping them in a box, all pupated in due course, and the adults emerged,

The wasp cocoons were seen from March to May, but were most plentiful in April.

(Taken from a Paper in "Australian Naturalist" by M. N. Brewster.)

PARASITIC WASPS.

C.—Family Braconidæ.

(Braconids.)

Characteristics (1).—The abdomen is not so mobile as in ichneumons; (2) the antennæ are not elbowed, and have more than 15 joints; (3) the wing differs from the ichneumons, in having the second space of the posterior or outer end of the wing, counting from the lower part of the wing, not divided into two cells by a transverse veinlet. (Plate 16, Fig. 5.)

These wasps can be seen by keeping "woolly bear" caterpillars in a box and the parasites may be reared out in many cases. The common type is *Microgaster,* a tiny dark wasp, the female with a long ovipositor, to enable it to reach down through the hairs to the body of the caterpillar. The larvæ (very tiny legless grubs) hatch out, and when full grown are only about one-third of an inch in length. As many as 50 to 80 eggs are laid in one caterpillar, according to the size. The grubs hatch out and feed on the juices of the victim either by sucking or by absorbing through the whole body. They do not injure any vital part while this is going on, and when at last the brood of parasites is reared at the expense of the victim,

the caterpillar has no strength or life left, for there remains a mere shell.

Most of the caterpillars we had under observation never reached the pupal stage, just living long enough to give food to the swarming parasites. We observed the tiny wasp maggots making their way out of the living, but exhausted caterpillar. They cut their way out, between the segments of the body, and began to spin little white cocoons on the hairs of the victim. (Plate 16, Fig. 1.) One could see their heads moving backwards and forwards as they spun themselves within their snug little resting places—their cocoons. This procession of emerging wasp maggots took place, and their cocoons were spun, until the poor caterpillar was covered with a layer of these little egglike structures. The adult emerges by pushing off the end of the egg as a cap (Plate 16, Fig. 4 a).

These braconid parasites are often themselves parasitised by chalcid wasps, and this double process is termed *hyperparasitism,* the second parasite, that is, the chalcid, being referred to as a hyperparasite. The braconid *Opius* attacks the Queensland fruit fly, and another, *Apanteles,* attacks the sugar cane moth.

Mr. Froggatt, in "Friendly Insects," says of the cocoons of braconids: "These cocoons often form a regular mass containing many hundreds enveloped in a mass of curious cotton wool like substance; however, the latter is often wanting. These clusters of little cocoons can be noticed on the grass-like stalks in fields where the cut worms have been

swarming; they are often thought by farmers to be "caterpillar eggs" and are destroyed by them in consequence. These cocoons should never be damaged, but preserved, for later on they will bring forth a crop of active little wasps, ready to kill many injurious grubs.

"There is another group of braconid wasps that are almost confined to plant aphides. They puncture the aphides and deposit the egg beneath the skin. The little maggot feeding inside the aphis soon empties out all the juice and then pupates. If one examines the insects upon an aphis-infested cabbage leaf, he will notice many aphides dry, discoloured, and apparently lifeless, of different colour to the living ones, and swollen and shapeless. These remain firmly attached to the surface of the leaf by their claws, and later on, the imprisoned wasp gnaws its way out through a hole in the side of the aphis skin, and comes forth a shining black wasp, ready to start fresh parasites among the remaining aphides. Nearly every species of plant aphis has some small *Apanteles* wasp parasite, that (late in the season in particular) will kill a very large percentage of aphides. Note that this large group of parasitic wasps do not sting. They can pierce the skin with their ovipositor in some cases, but there is no poison ejected."

FAMILY CHRYSIDIDAE.

Ruby Wasps. (Plate 16, Fig. 10.)

They are beautiful greenish metallic wasps whose integument is so hard as to be called the "armour-plate" of the insect world.

Eggs are laid in the nests of bees and other wasps and should this enemy be attacked by them, she curls her body round presenting the armour-plate of her back and sides to the pursuer. Ruby wasps have a sucking mouth. (Plate 16, Fig. 9.) In America these ruby wasps are called "cuckoo flies," and J. H. and A. B. Comstock, in the work, "A Manual of the Study of Insects," write in describing these insects: "The abdomen is convex above and flat below so that it can be readily turned under the thorax and closely applied to it. In this way the "cuckoo-fly" rolls itself into a ball when attacked, leaving only its wings exposed.

Although these insects are handsome they have very ugly morals, resembling those of the bird whose name has been applied to them. A cuckoo-fly seeks until it finds one of the digger wasps or a solitary true wasp, or a solitary bee, building a nest, and when the owner of the nest is off collecting provisions, steals in and lays its egg, which the unconscious builder walls in with her own egg. Sometimes the cuckoo-larva eats the rightful occu-

pant of the nest, and sometimes it starves it by eating up the food provided for it. The bees and wasps know this foe very well, and tender it so warm a reception, that the brilliant-coated little rascal has reason enough to double itself up so that the righteous sting of its assailant can find no hole in its armour. There is one instance on record when an outraged wasp, unable to sting one of the cuckoo-flies to death, gnawed off her wings, and pitched her out on the ground. But the undaunted invader waited till the wasp departed, and laid her egg in the nest before she died. Some of the cuckoo-flies are true parasites; one of them infests the currant worm in Europe."

Mr. W. W. Froggatt, in "Australian Insects," says: 'Some of the earlier observers called them "cuckoo-wasps" under the impression that their larvæ when hatched out in the nests of hunting wasps or bees that filled the cells with insects, or bee bread, fed upon the stored food supplies. But later researches show that, though the eggs of both the lawful occupant and the intruder may be deposited in the cell, the latter does not hatch out until the former has devoured all the food placed there by his mother, and is ready to pupate; then the ruby wasp baby comes out, attaches itself to the full fed larva beside it and sucks him dry pupating in his skin." He also records that ruby-wasps bred out by him were parasitic on smaller mason wasps, example *Odynerus* and *Alastor*, though in Europe many species live in the nests of bees.

We bred out the ruby-wasp (Plate 16, Fig. 10) from the nest of a mason bee. From one cell the adult ruby-wasp emerged, and in another cell there were the two larvæ present in the cell—the bee larva and a smaller ruby-wasp larva. We examined the "bee bread" from the cell of a young grub and found that the pollen grains (white) were those of some Myrtaceous plant such as *Leptospermum* (Tea Tree), *Melalenca* (Tea Tree), or small flowered *Eucalyptus.*

On examining the mouth of this ruby-wasp we found that it had a fairly long, broad tongue which was segmented and had two pairs of conspicuous palp-like structures. (Plate 16, Fig. 9.) It is probable from this that these wasps suck up honey or nectar of flowers. The larva pupates within a silken cocoon shutting out the excretion. (Plate 16, Fig. 11.) It is well worth while keeping nests of mud-wasps or bees, and to note how many parasites may be recorded. We keep them in boxes sometimes for a year, and are usually rewarded by the presence of some adults of the builders of the cells, and very often a fly or wasp parasite, or both.

PLATE 18.

Fig 1 Larva

Fig 2 Spring hair of Larva

Fig 3 Pupa (naked)

Fig 4 Pupa in Cocoon one half removed

Fig 5 Head of Ant
a Mandibles
b Basal Joint

Fig 6 Golden-bodied Ant (*Polyrhachis*)
a Spine
b Node

Fig 7 Abdomen of Bulldog Ant
a Constriction
b Sting

Fig 8 Adult
a Node

ANTS (enlarged).

GROUP HETEROGYNA.

Family Formicidæ.

(Ants.)

Ants are supposed to have had as ancestors certain of the solitary wasps, and in some of the more primitive types of ants, such as the Family Poneroides (to which bulldog ants belong), and Family Dorylides (driver and legionary ants), a few of the habits of the wasps are retained. For instance, these primitive ants are usually carnivorous, and feed their larvæ on the flesh of insects, etc.; they hunt for their prey, singly, in many cases; their nests are usually small with few in a colony (exception to the latter is the bulldog ant and some of the Dorylides). Many of these primitive ants retain the old wasp-habit of spinning cocoons (by the larvæ), which custom has been rejected by the more specialised ants.

Ants can be distinguished from wasps by the presence of a **node** (Plate 18, Fig. 8, a.) or knob on the petiole of the abdomen. The antennæ are elbowed, with the first joint (in the females) greatly elongated (Plate 18, Fig. 5.b.) With the exception of a very few parasitic forms, ants are always social in habits. They live in colonies and have the social instincts very highly developed. There are three **castes**, males, females and workers. In some cases the

workers are further specialised to form (a) soldiers, (b) nest workers. The latter are sometimes smaller in size than the soldiers, example the sugar ant (*Camponotus nigriceps*). In other species there is practically very little difference in size between the workers and soldier-workers — example: greenheads (*Ectatomma metallicum*). The workers are wingless, and either have a sting or an ejaculatory organ from which formic acid can be ejected. Upon them devolves the whole care of the nest. Workers are aborted females. It is because of this variety of type in the female ants that the name *heterogyna* is given to the group, for there are queens and workers, and the latter are often specialised into soldier workers and nest workers.

Formation of a Colony.

When the time has come for the founding of new colonies, males and females are hatched in the old nest, and on some very warm evening the males and females prepare to set out on the "marriage-flight." There is great excitement in the nest, and the workers rush about and accompany the departing males and females to the door of the old home to see them start off. After this nuptial flight the fertilized females drop to the ground, cut off their wings, and each seeks a place to start her new home. But a large number of these queens are seized by waiting insect enemies, and the males also fall victims to insects and birds, or drop into water.

We will follow the recorded life history of a queen

ant which has just fallen. She digs (often with difficulty) through the soil in some sheltered spot, making a little tunnel which she closes from the outside, thus shutting herself in. She proceeds to enlarge the end of the little passage at the far end and makes a little chamber where she rests till the eggs in her body mature. This waiting may last for months. Then she lays some eggs in the chamber and the larvæ hatch; they are small undersized ant babies (legless grubs), and they often take a very long time to mature, sometimes nine months. They pupate and then emerge as undersized worker ants. Now where did the queen-mother ant get the food to feed her babies? She had concentrated food supplies stored in her body, so you see that female ants must be well fed and cared for before they leave the old home, because they have to live for nearly a year without any food except what is stored in the body. During all the long period of waiting, of hard work in rearing her brood, she took no food from outside, for she was locked up in her little underground home. This scheme in founding an ant colony protects the queen and young babies from enemies, for it is difficult to locate such a home.

But now the workers are hatched and they soon get to work to help their overworked mother. They cut a way out from their temporary prison by making an entrance to the nest from the outside, they build new passages and enlarge the nest and now forage for food, they also feed the ant-babies, look after their mother and take the whole

management of the home on their shoulders. The queen or mother never leaves the nest and grows timid and avoids the light. She just lays the eggs and the workers remove them to the "egg chamber."

Sometimes a "mother" is found by some of the workers of the old nest, and they then stay with her and help her found a new colony. The mother's life is not then so strenuous. In some cases two or three ant-mothers from the "summer flight," get together under a stone, etc., and they together found the new home which starts with three queens instead of one, for ant queens always live amicably together, differing from bees which have only one queen in each hive. Not every mother-ant who starts a nest is able to finish it, for some are not well nourished and have not the strength or food-supply in the body to enable them to keep the nest going, and so during the long waiting period while the eggs mature and the babies are being fed, the food supply gives out, and the babies and mother die. So that out of the numerous female ants which fly from the old nest, only comparatively few succeed in founding a new ant colony. Ants have the advantage over most other hymenopterous insects in the convenient positions of their nests, and of materials from which their nests are made. Bees and wasps have to hunt for materials and work these up gradually in order to build their cells. But most ants use the soil as it stands, as material, or build in the sand under stones, logs, etc., and are protected by these.

The food of ants is more varied also than that of bees and wasps. It is known that ants were originally carnivorous in their habits, and a few more primitive species of ants still retain their old habits, (*ex.*, bulldog ants, driver ants). Most ants however, have a very varied diet, and can feed on insects, spiders, etc., but they also enjoy nectar of flowers, juices of fruits (when bruised). Some ants seem particularly fond of flower nectar, or honey dew. We have seen ants, such as *Iridiomyrmex detectus* (gravel or mound ant) on a tall mulberry tree, sipping at the juices of bruised mulberries. Some ants are very fond of the sugary secretions of insects, such as the "sugar-lerp," a psyllid which secretes a little white brittle scale on leaves of *Eucalyptus*. Of these we have noted large numbers of the gravel ant (*Iridiomyrmex detectus*) and, a dark looking sugar ant (*Camponotus aeneopilosus*; also fewer individuals of the golden-bodied ant (*Polyrhachis ammon*). Ants also visit the honey-dew froghoppers of genus *Eurymela* which are often quite hidden by the ants which surround them. Of such we noted the gravel ants, which formed regular processions from their very large nests (which were in several clusters extending over about eight yards) to the group of small Eucalyptus trees which were about fifteen to thirty yards away. The sugar ant (*Camponotus nigriceps*) was also present, and also *Polyrhachis ammon* (golden-bodied ant), but fewer of these species. An amusing incident occurred as we were watching these ants. We saw a solitary black bulldog ant (*Myrmecia tarsata*) walk-

ing round a leaf. It stepped across to the next leaf on which was a single gravel ant (*Iridiomyrmex*). The gravel ant rushed at the bulldog ant, and the latter hastily retired to the nearest leaf. A friend who was also watching remarked: "Well, I have never seen a bully so easily worsted." We saw also a tall Eucalyptus tree badly infested with the loose cottony scale which was on branches and leaves, and the gravel ants (which we traced to a nest near) were literally swarming over the tree.

Another curious example of special food is seen in tropical America. A group of ants called the Attii cut off pieces of leaves of plants, cut and knead them and place them in their nests. Fungi grow on these and the ants feed on this growth, and feed the ant babies with semi-masticated fungal material. In Mexico these ants cause considerable damage in defoliating certain trees.

The varied diet of ants enables them to live without making large stores. There are examples of ants which store food, however, the "Harvesting Ants" which feed on the seeds of grass and cereals, have special chambers set apart as "granaries." The larvæ and the adults are fed from the stores, and as the diet is restricted it is necessary to store the seeds while they are in season.

A wonderful example of a living store house is seen in a species of *Camponotus*. (See Plate 20, Figs 3 and 4.) It is figured and described by Lubbock in his "Bees, Ants and Wasps." Froggatt thus describes our Australian example: "The ordinary members of the "honey pot" ant are of the usual

normal form, but certain individuals of each nest of the species are crammed with a honey secretion (probably obtained by the workers from aphids and psyllids), until the abdomen swells out of all proportion to the rest of the ant; the "honey pot" ants remain hanging about the bottom of the nests like a number of bottles of honey, incapable of leaving the nests; the supply is probably used as food for the larvæ. Baldwin Spencer says that the blacks dig up these nests and look upon the "honey pots" as great luxuries. The honey is sweet with an acrid fluid, which tastes like the honey of our native bees. They are apparently common in central Australia.

Food of the Larvæ or Ant Grubs.—The food of the larvæ of many ants is also varied. As before mentioned the more primitive ants feed the ant-babies on flesh, just as they eat it themselves (bull-dogs and driver ants). Most ants feed their larvæ on regurgitated food. Certain species, such as Camponotids (*Polyrhachis* and *Camponotus*). Dolichoderids (*Iridiomyrmex* and *Dolichoderus*), feed their larvæ only by regurgitating liquid food from their mouths. We have observed these ants on honey dew on leaves, seeking the nectar of flowers such as the pigeon berry (*Monotoca*), grass tree (*Xanthorrhoea*), *Leptospermum*.

Other ants feed their young on both regurgitated liquid and on solids so that in times of dearth of certain foods, they can adapt themselves to other kinds.

The Nests of Ants (Plate 19).—The nests of ants are usually in the ground, and the arrangement and size of the nest depends on the species of

Hymenoptera - Nest of Ant (After Em. Andre)
a Egg Chamber, b Larval Chamber, c Pupal Chamber.

ant. There are usually several chambers from which are connecting passages. The eggs, very young larvæ, older larvæ, pupæ, may be placed in separate chambers, or if in one large irregular chamber, then they are put into separate groups. As one would expect, the more primitive ants have simpler nests. The ants are continually moving the brood, bringing certain groups either higher up or taking them lower down, according to the weather conditions.

We have found nests in rather curious places. One nest was formed under a small pot with a fern growing in it. Part of the nest was in the ground under the pot and part of it was in the soil of the pot. We took the earth from the pot (it came out clean), and on gently breaking it across saw the passages with groups of larvæ, pupæ, and very tiny eggs, which the ants were quickly removing into the recesses of the mass of soil and roots.

One ant colony was happy in a half hollowed out potato where the irregular inner surface served as "rooms" for pupæ and larvæ. The ants lived here for months, for the potato was sheltered by the dense mass of dead leaves of a yucca plant.

Another curious nest was found in a large woody gall that was hollowed out at the apex. It was a very small colony of tiny black ants, and they lived here for nearly 18 months with very little food supply. Then the gall was knocked over and the family scattered.

On the Blue Mountains we found many nests of ants at the base of tiny shrubs which were in-

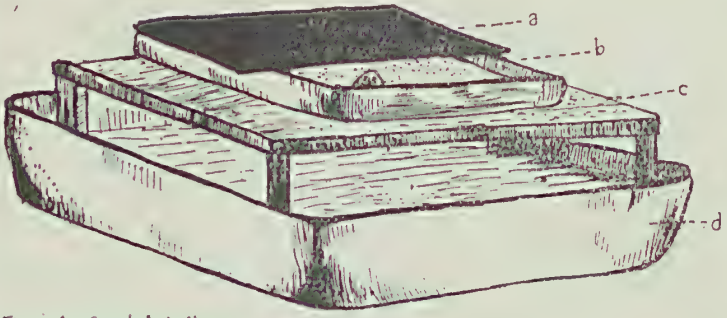


Fig 1. Artificial Ant Nest
a. Glass b. Box
c. Support. d. Dish with water

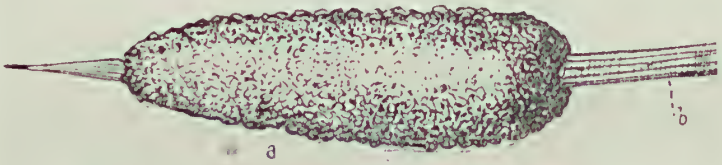


Fig 2. Blade of Porcupine grass with Ant case (After Spencer)
a. Ant Case b. Blade of grass.

Fig 3 Honey Ant feeding workers (After Mc Cook)

Fig 5. Leg of Ant - Camponotus
a - comb

Fig 4. Honey Ant (Melophorus inflatus) After Spencer.

Fig 6. Comb Enlarged.
a. Comb on Tibia
b. Comb on Tarsus.

ANTS (enlarged).

fested with a loose cottony scale, and the ants built up a covering of sand around a branch, and so protected the scales and enabled the ants to pass freely under the covering. We transported one of these nests and kept it under observation for some months. Professor Spencer, in "Across Australia," describes the nests of certain ants which had special store ants or "honey pots." "One of these nests has the form of a mound upwards of 2ft. in diameter and about six inches high, with a large crater-like depression at the top. The ants arrange a thick deposit of the long dry phyllodes (so called leaves) of the mulga tree, so as to cover the dome. They are all placed in a perfectly radial manner, and give the nest a most characteristic appearance.

"Another nest had a mound of the same size, but instead of a crater opening, it had a slit five or six inches long and half an inch wide. The mound was covered with an enormous number of grass seeds, every one of which must have been brought in separately by the insects, which is one of the many species of the genus **Camponotus** (*Camponotus denticulatus*). We spent some time investigating the nest, but the ground was as hard as stone, and the insects, which were one-half or threequarters of an inch in length, disliked being disturbed. There did not appear to be anything like a fungoid growth among the leaves or seeds, or anything that we could see which would be of service to the ants, though such might, of course, be present under different conditions in regard to moisture. Often these two kinds of nests would be close together,

but the one always had nothing but mulga leaves, and the other nothing but grass seeds."

Professor Spencer gives an interesting account of the nest and habits of the porcupine-grass ant (*Hypoclinea flavipes*) found in the desert area of Central Australia.

"Various explorers have already noted the presence of curious little galleries which run along the surface of the ground, often for long distances, from one tussock of porcupine grass to another. In some parts, and especially on hard, sandy soil where the tussocks of grass are not too close together, these galleries, as they are called, though tunnels would be a better name, form a regular network. Each is from one quarter to half an inch in width, and, in section, is roughly semicircular in shape. They are made of grains of sand fastened together with the resinous material obtained by the ants from the gelatinous leaf sheaths of the *Triodia* (porcupine grass), and they form runs which lead from one tussock to another, along which the ants can travel sheltered from the light, and more especially, perhaps, from the heat of the sun. In many cases they lead for long distances up the trunks of gum trees.

In addition to the galleries running along the ground some of the tussocks of porcupine grass have their long spiny leaves more or less wholly enclosed in little cylinders of sand, formed in the same way, to such an extent that the whole tussock looks like a network of sand tubes. In other cases there were only small cylindrical cases of sand here

and there on the spiny leaves. (Plate 20, Fig. 2.) Each of these was perhaps half an inch or an inch long and a quarter of an inch in diameter, and so built that the grass blade formed one part of the wall, a space being left enclosed between it and the sand. The cylinder was always closed at the top and had a small opening at the bottom so that if rain came it would not get into the chambers.

Watching the ants which are very small and black-bodied with yellowish feet, I saw them running in and out of these chambers, and on opening the latter, found that they were always built over two or more Coccidæ (Order Hemiptera), attached to the leaf of the grass. Here, as in the case of the ants described by Belt in Nicaragua, the Coccidæ abstract nutriment from the leaf, and the ants take advantage of the exudation from the body of the Coccus. This arrangement is without doubt of advantage to both parties concerned. The Coccidæ gain protection from enemies to whom they are made invisible, and also from the great heat of the sun, and at the same time the ants get without much trouble to themselves a supply of food."

Life History of Ant.

The eggs are laid by the mother and are moistened by salivary fluid which enables the eggs to cling together, and it has been suggested that the fluid is probably antiseptic, preventing the growth of fungi, etc. Thus the eggs are more easily carried when being removed, for they are very tiny, most people mistaking the pupæ for eggs. The

eggs are usually placed in the warmest part of the nest, in the upper chamber, in the day-time at least. The larvæ hatch out and are tended and removed by the workers, who clean and feed them and lick them all over with the salivary fluid. These "nurse" workers attend the larvæ all through the day, remove them from chamber to chamber according to the need.

The larva (Plate 18, Fig. 1) is a creamy-white legless grub, or hymenopterous maggot. It differs from the typical maggot of the Order Diptera (flies), in having the head and thorax bent over on its body. It has no eyes, for it is in a helpless condition, entirely dependent on the workers for food and care. It has well formed mouth parts, and spiracles or breathing pores. Like most insects it has hairs disposed over its body, and in some cases there are elongate curious "spring" hairs which are curved and have a hook at the free end. (Plate 18, Fig. 2). The hook fastens on to the earth or medium on which they are lying and the whole construction of these spring hairs prevents the jarring or tearing of the delicate larvæ, when the workers rush to seize them and carry them away if the nest is disturbed. When the larva is full grown it pupates, either as a naked pupa (Plate 18, Fig. 3), or with the pupa enclosed in a cocoon. (Plate 18, Fig. 4). In those species whose larvæ spin cocoons, the workers place the full-grown larva in loose sand, where it makes a hollow by twisting and pressing, and in this hollow it begins to form the cocoon by fastening threads to the sides

of the hollow. It gradually disappears within this rather tough cocoon, and the busy workers remove it to the "pupal chamber," where the cocoons or pupæ are kept by themselves. When the adult is nearly ready to emerge, the workers seem to be able to find out, for they go round (in some species) and tap the pupæ with their antennæ, and when the time of emergence is come they cut open the cocoon and aid the adult (either male, female, or worker) to emerge. This is described in detail later on.

The Worker Ant.—The worker ants are just as clean and careful over their own bodies as they are of the larvæ, queen, and newly emerged adults. Nature has fitted them with wonderful appliances to enable them to do this. There is a **comb,** or strigil (See Plate 20, Figs. 5 and 6.) This is a highly modified tibial spur (a spur on the tibia or fore-leg) of the front legs. It is a semi-circular comb with teeth present. On a very enlarged joint of the foot is a corresponding semi-circular structure and these two combs fit together to form one circular comb. The hind pair of legs and the antennæ are drawn through this to remove any adhering particles of sand, etc. This is very necessary to ants which live in sandy soil. The ant may also have a tuft of hairs on the lower surface of the head, and these hairs are "comb-cleaners." Professor Wheeler says that "the combs are passed along these hairs just as we clean a comb by means of threads." We noticed that on all the legs of *Camponotus* and *Myrmecia* (bulldog ant) there was a

tibial comb, but the one on each of the middle and hind legs was much more elongate and with coarser teeth. On each of the front legs of the worker of *Camponotus nigriceps* is a very beautiful comb (Plate 20, Figs. 5 and 6 a. and b.).

We see that the workers are the mainstay of the nest. They nurse, clean, build, carry, forage and fight. In some species of ants the workers are known to carry up the broods to give them an airing on very hot summer nights. In other species it is recorded that some of the workers have a curious habit of going out to meet the home-coming foragers who are late and seem tired or stranded, and they lift them bodily and carry them home, and the comrade who is being carried seems quite content and does not struggle.

Ants do not often change their nests, for they may occupy the same abode during the lifetime of a man. The life of the individual ant, too, is longer than that of an individual of bees and wasps. A worker lives from four to eight years, and a queen from thirteen to fourteen years.

When a change of nest is made, it is the workers who do the work. They remove eggs, larvæ, pupæ, queens and males, bodily to the new abode, and it is said that should some of the workers object to go to the new nest, or wander back to the old one, they are carried bodily to the new home. To show the general intelligence of the ant, the following is taken from "The Study of Insects," by J. H. and A. B. Comstock: "They have a language which seems to exist through the sense of

touch. The antennæ are most sensitive organs, and when ants meet they cross their antennæ and pat each other. If one finds some large article of food, too heavy for it to carry, it goes forward, and the first fellow it meets it pats with its antennæ, and the two start off together for the booty. If a nest is attacked, the workers or soldiers rush around and stroke each other with their antennæ, and thus evidently give warning or plan a battle for protection. In case an ant finds a comrade in distress it shows great solicitude and activity in giving relief. Yet there are some species that, like the Spartans, kill off the feeble and old, as useless to the colony. When a portion of the colony is removed and kept imprisoned for a time and then returned, there is great rejoicing on both sides. Gould says they have a way of standing on their hind legs and prancing round under such circumstances, as well as when they enter the cell of their queen, that indicates great joy. Sometimes they get to be very hilarious and wrestle with each other, and carry each other around, as if it were a part of a game they found amusing—a kind of formic football."

Ants and their Protection from Enemies.—Ants can defend themselves either by biting with their mandibles, or by means of a powerful sting. Wheeler thus records their habits in this respect: "The mandibles are the principal weapons of defence, and these in the larger species of *Camponotus* and *Atta* are sometimes employed with telling effect. In the Myrmicinæ (*Monomorium*, the little red meat-ant, belongs to this group), and the Ponerinæ (bull-

dog ants), their action is often supplemented by that of a well-developed sting. Many species of *Formica* spray their enemies with formic acid, or inject it into their victims by moving the gaster (thicker part of the abdomen) forward and centering its tip on the wound made by their mandibles. In battles with other species or aliens of their own species they pull their opponents' legs or antennæ with their mandibles and spray the tense membrane between the joints. Enough of this acid is absorbed to cause temporary paralysis or death. The Dolichoderinæ (to which our gravel or mound ant belongs), and some Myrmicinæ smear their victims with a maloderous secretion from the anal gland, which seems to have an equally irritating and obnoxious effect. While in many species some or all of these aggressive measures may be adopted by the workers in general, other species have a specially protective caste in the soldiers (*Camponotus* and *Atta*, etc.)"

Many of the weaker colonies of ants take refuge in flight. In almost every species of ants some of the workers rush away with the larvæ, pupæ and eggs as soon as the nest is disturbed, even when the soldier workers or ordinary workers show resistance. But some species of ants are timid and rush at once into the inner passages of the nest without offering fight. Other species of ants feign death. Almost every log and stone shelters ants' nests, and the rushing away with pupæ and and larvæ can be seen on lifting the stone.

With the exception of their own kind, ants have very few enemies.

The larvæ of ant lions either wait in the sand or build little pits in the sand and seize any luckless ant, passing that way.

The Echidna or Spiny Ant-eater also feeds on ants, and their eggs. It has a long slender tongue which is covered with sticky saliva and this enables it to capture numbers of ants.

The Marsupial Mole and the Banded Anteater also feed on ants.

Mymecophiles or **Ant Lovers.**—These are a variety of little creatures which inhabit ant colonies either in a state of commensalism (for mutual good), as parasites, or as scavengers.

We have mentioned such insects as aphids and scales which give off secretion pleasing to ants, and in return are protected by the very presence of the ants (for ants have few enemies). The aphids are the most commonly known, and are often called "ants' cows," for some species of ants store the eggs of aphids during the winter weather, and when the spring comes and the aphids hatch out, they carry them out to their food plant or "pastures," and then in return gather the honey dew given off at the tip of the abdomen. Some ants specially protect aphids which feed on the roots of plants, and these species place the aphids in the ant nest at night and carry them on to the roots in the daytime.

There are some species of beetles which live in the ants' nests, some being harmless, and live on

the refuse of the ant, while others are parasites and live on eggs and larvæ of ants, and will even attack adult ants if alone. Some of these show mimicry of ants. The Rove beetles (Staphylinidæ), which are found in ants' nests are among their worst enemies.

There is a species of silver fish which lives on the regurgitated fluid which is given out by one worker to feed another. This insect creeps up between them and steals the drop of fluid. Its smooth, slippery coat affords a means of escape when fleeing from its enemies.

True parasites such as mites are seen on the bodies of ants, on which they take up definite positions.

Chalcid and braconid wasps are known to parasitise certain ants. Parasitic worms have also been recorded.

Myrmecophiles of the nests of certain ants have been recorded by Mr. E. H. Zeck in the "Australian Naturalist of New South Wales." These nests were found under stones and bark. Mr. Zeck says:—"Usually when first collecting, many species of beetles are passed over; owing to their protective colouration and their remaining quiet for several minutes before moving, the members of the Genus *Chlamydopsis* being perhaps the most difficult to detect—in fact, they may even be turned over among the debris without showing a sign of life. The legs, antennæ and head are withdrawn into the cavities of the body. After examining the nest the stone should be replaced so as to permit of re-

examination at some future time. The insects when caught are best placed in small tubes of methylated spirit, along with some of the ants in whose nest they were found. A dry grass stem, dipped in spirit, is excellent for picking them up. Later they are gummed on small cards with the legs and antennæ carefully spread out, and one or more of the ants should be placed on the same card, through which a pin is run. A small label, with locality and date, is placed below the card. The gum must be used very sparingly."

Mr. Zeck has recorded individuals from nearly every order in the nests of different species of ants.

Classification of Ants.

Group Heterogyna (different types of females).

Family Formicidæ (insects which may secrete formic acid.)

A. Sub-Family Ponerides. To this Sub-family our "bulldog" ants belong.

Characteristics: The hind body is elongate and often slightly constricted between the 1st and 2nd segments of the abdomen (Plate 18, Fig. 7, a.); a sting is present (Plate 18, Fig. 7, b.) and usually very powerful; cocoons enclose the pupæ. **Types** *Myrmecia* ("bulldogs"); *Ectatomma* ("greenheads").

These Ponerid ants are a very primitive type. Froggatt thus describes our bulldog ants: "The Genus *Myrmecia* contains most of our largest typical species peculiar to Australia and popularly known as "bulldog ants," "Inchmen," or "Jumpers." The

"Jumper" (*Myrmecia albo-cinta*) forms its nest under the shelter of a low bush: it is a low mound with an opening on the summit and another on the side, level with the ground. When disturbed these ants come running out like a pack of dogs, with a series of short jumps, and attack everything they meet" . . . *M. forficata* (the red and black bulldogs) live in rather large colonies up to 200 in number, digging deep circular shafts or irregular channels under logs; when away from the latter they form regular domed mounds over the nests which in summer contain the large elongate, oval brownish sacs containing the pupæ, and often a number of winged males and females.

M. tarsata, or black bulldog ant, is found running up and down the larger tree trunks, and drops to the ground at the slightest alarm; when disturbed in the nest, if the first two or three are captured, the others retreat to their burrows and do not show fight like others of the species."

M. gulosa is the red bulldog ant..

The "Greenhead," *Ectatomma metallicum* is common in grassy lands and gardens: it stings very severely.

B. SUB-FAMILY DORYLIDES.

(Wandering, Driver or Visiting Ants.)

These ants are nomads, having no fixed place of abode, never resting more than several days in one place. There are two groups (a) the Dorylus Group, found in Africa and some species in Asia also; (b) the Eciton Group, which is found in America only. The males, females and workers differ remarkably. The female is usually very large and is blind: the workers are blind, like the female, or with rudimentary simple eyes. There are sometimes two worker castes, the soldier type, large and with strong, long mandibles; the smaller worker, whose mandibles are suitable for industrial purposes.

The Dorylus Group is represented by genera *Dorylus*, *Anomma*, and *Aenictus*. Savage describes in a very interesting manner the habits of Driver Ants in Africa. They march in huge columns, and will pass through houses, ridding them of vermin, meat, etc., for they are carnivorous types. Savage says that if confined they will attack animals such as large lizards, snakes, and even monkeys and pigs.

Belt thus describes the habits of one of the Ecitons (the American type): "One of the smaller species (*Eciton praedator*) used occasionally to visit our house, swarm over the floors and walls,

searching every cranny and driving out the cockroaches and spiders, many of which were caught, pulled or bitten to pieces, and carried off." The same writer observed their habits in the forests: "On the flanks and in advance of the main body, smaller columns would be pushed out. These smaller columns would generally flush the cockroaches, grass-hoppers and spiders. The pursued insects would rapidly make off, but many in their confusion and terror would bound right into the midst of the main body of ants." He then describes how the insects would climb the trees and for a time escape their merciless enemies, until at last the ants would climb the trees and chase their victims to the tips of leaves, etc, till they dropped into the jaws of the main body of ants below. Spiders sometimes escaped by spinning a thread and hanging in mid-air.

Driver Ants form living tunnels through which the smaller workers pass, laden with food. Savage thus describes them: "In cloudy days, when on their predatory excursions, or migrating, an arch for the protection of the workers, etc., is constructed by the bodies of their largest class (soldiers). Their widely-distended jaws, long slender limbs, and projecting antennæ intertwining, form a sort of network that seems to answer well for their object. Whenever an alarm is given, the arch is instantly broken, and the ants, joining others of the same class on the outside of the line, who seem to be acting as commanders, guides, and scouts, run about in a furious manner in pursuit of the

enemy. If the alarm should prove to be without foundation, the victory won, or the danger passed, the arch is quickly renewed, and the main column marches forward as before in all the order of an intellectual military discipline."

This sub-family of ants is thought to be closely connected with the Poneridæ.

It is only represented in Australia by two species of the Genus *Aenictus* which are found in Queensland.

C. **Sub-Family Myrmicides.**—Characteristics.—The females are large and winged; the petiole is two jointed (has 2 nodes); the pupæ are always naked, with no cocoons. Small or medium sized ants, example, *Monomorium*, the little red meat ant.

D. **Sub-Family Dolichoderides.—Characteristics.**—Petiole with one node; no sting, it is only rudimentary, but instead there are anal glands which secrete a characteristic odour; pupæ are naked, never in cocoons; examples are *Dolichoderus* (the "honeydew ant"); *Iridiomyrmex detectus* ("mound or gravel ant").

The Gravel Ant has an iridescent sheen (hence its name), and it makes large mounds of gravel—sometimes there are several nests adjacent and extending over 25 feet. They are strong runners, having regular tracks over grass lands so as to make a narrow footway across a paddock. We have watched them running in pathways from the nests to eucalyptus trees near, where dozens would be clustered around groups of froghoppers and lerp

scales. Quite a large tree was practically swarming with these ants which were feeding on the honey-dew secreted by a soft white scale. We have found them on the flowers of the "pigeon berry" shrub (*Monotoca scoparium*), and on the spike or the Grass Tree (*Xanthorrhoea*), in the latter case several seemed helpless owing to the abundance of the nectar they had imbibed. *I. rufoniger* is a pest in the summer time, finding out honey, jam, etc., which may be left where these ants can reach. We have found smearing kerosene around the pantry a sure remedy for these visitors.

There is one species of Dolichoderid which has some of the workers modified to form "honey-pots," but it is not so distended as the *Camponotus inflatus* mentioned before. It is found only in Australia and New Guinea; its name is *Leptomyrmex rufipes*.

D. **Sub-Family Camponotides.**—Petiole with one node; no sting, but a poison sac is present in the worker and female. The poison gland forms a flat oval cushion at the anal end. Formic acid is secreted, and the pad is used as an ejaculatory organ. Cocoons usually formed, but sometimes the pupæ are quite naked. The Sugar Ant, *Camponotus nigriceps* is our best known example. It is a yellow and black ant.

In most of the Camponotids there are two worker castes, large **soldier-workers,** and smaller **forage** and **nest-workers.** These ants are found under stones and logs, and are very good types to observe in the house, for they soon settle down to their new conditions. We have found some of the

smaller sugar ants on the honey-dew insects, but usually few in number. However the species *Camponotus aeneopilosus* we have found in numbers around froghoppers. Some of these ants live in a state of commensalism with the caterpillars of the butterfly, *Ogyris* and of *Jalmenus*.

The integument of most Camponotids is soft and flexible, and some of the workers become living "store-houses" for the reserve honey of which they are so fond. These ants are found in the hot interior of Australia, and they store these sweets for the dry barren summer months, when the country is baked and dry. The workers who forage bring in the nectar, or the honeydew, and regurgitate it to these "repletes," or store workers. The bodies of the latter distend and form "honey jars." They can only move very slowly, and generally remain on the floor of the nest like tiny balloons with a stalk attached. This honey is regurgitated to the workers by the repletes or store ants, and so the colony is kept alive during the droughts.

One of the honey ants, a Camponotid (*Melophorus bagoti*), is found in the interior of Australia. Some of the large workers are set aside to act as honey-storers, but their bodies are not so inflated as those of *Camponotus inflatus*, hence they move more readily.

Professor Spencer, in "Across Australia," thus describes these honey ants:—

"We came across the burrows of a honey ant (*Melophorus inflatus*), an insect which we were most anxious to see in its native habitat. There

is nothing on the surface to indicate the existence of a burrow, except a little opening about an inch in diameter. From this, the central burrow runs down. The natives soon found one or two, and immediately set to work to dig them out. It was astonishing to watch the speed with which the elder woman worked. First of all, the ground around the opening was loosened with a digging stick held in the right hand close to the lower end. The earth was scooped out with the aid of a small wooden bowl held in the left hand, and alternately loosening the soil with the stick and then throwing it behind her, the lubra soon sank a hole just big enough to hold her body. The main burrow went down between five or six feet with horizontal passages going off all around it. A few of the honey ants were found in each of these, but the greater number were in a swollen chamber at the base. In the nests which we dug up we only found two kinds of ants, one of the ordinary worker." There is an American species of honey ant, and the honey is obtained by the workers. "The honey is a product of a small gall found on the oak leaves, and is obtained by the worker ants during nocturnal expeditions from which they return much distended; they feed such workers left at home as may be hungry, and then apparently communicate the remainder of the sweet stuff they have brought back to already partly charged "honey bearers" left in the nest . . . the creatures move but little and remain suspended from the roof of a special chamber." (Sharp.)

A common camponotid is *Polyrhachis*, or the

"golden ant." The nests are often found under stones and logs. The larvæ and cocoons are easily obtainable, and these ants are good types to set up in simple artificial nests, as they settle down comfortably after the first rushing round. The genus can be distinguished by the prominent spines on the thorax and node (See Plate 18, Fig. 6 a), hence the name "Polyrhachis." These ants are fond of honey-dew; we have observed them on the nectar secreting froghoppers and lerp insects.

Formica is a species of camponotid found all over the world, and some of these are slave hunters.

Oecophylla is an interesting camponotid which "sews" the edges of leaves together to form a nest and as the adults cannot produce silk to do this they have an ingenious method of using their larvæ for that purpose. A set of workers hold the edges of the leaves together, while other workers come along holding a larva, and the latter spins the thread to hold the edges of the leaves. Froggatt records, "They live in large communities among the foliage of the trees, in nests formed by webbing the leaves together into an irregular mass, varying in size from a cricket ball to a man's head. The worker for its size is the most pugnacious creature in the insect world; if one damages a nest pushing through the scrub, down tumble a swarm of Green Tree Ants on one's head and neck, and wherever they drop they stick their jaws in and hang on, and each one has to be picked off in detail. In these forests they destroy an immense number of insects, catching the little bees as they come out of their nests

in the tree trunks, and dragging the small beetles off the twigs by main force." They are found on the North Coast of Queensland and in New Guinea. They are tropical ants and are also found in India and Africa.

Slave Making Ants.

These are interesting ants and are often called "Amazons." The true Amazons are almost incapable of living without slaves, while others can manage for themselves should no slaves be available. Wheeler thus sums up the work of Huber and Forel on the Amazon *Polyergus rufescens*. "The mandibles are not adapted for digging in the earth or for handling the thin-skinned larvæ or pupæ and moving them about in the narrow chambers of the nest; but are admirably fitted for piercing the armour of adult ants. We find, therefore, that the Amazons never excavate nests nor care for their own young. They are even incapable of obtaining their own food, although they may lap up water or liquid food when it happens to come in contact with their short tongues. For the essentials of food, lodging and education they are wholly dependent on the slaves hatched from the worker cocoons that they have pillaged from other colonies. Apart from these slaves they are quite unable to live, and hence are always found in mixed colonies inhabiting nests whose architecture throughout is that of the slave species. Thus the Amazons display two contrasting sets of instincts. While in the home nest they sit about in stolid idleness, or pass the long hours

begging the slaves for food, or cleaning themselves and burnishing their ruddy armour, but when outside the nest on one of their predatory expeditions, they display a dazzling courage and capacity for concerted action compared with which the raids of Sanguinea (a group of slave making ants which can yet obtain their own food) resemble the clumsy efforts of a lot of untrained militia."

The slavery of ants is thus described by Comstock: "There are several species of ants which are slave holders, and by a strange coincidence the slaves are dark coloured, while the masters are light. When a depredating army sets forth, it proceeds to the black colony which defends itself fiercely; if the besieged blacks are overcome the conquerors carry off all the larvæ and pupæ to their own nests and bring them up with their own, and they in turn work hard for their captors, and take a great interest in their welfare and success. When a party of marauders comes back without any booty their slaves give them a cold reception, but if they come back laden with plenty of larvæ and pupæ, the slaves rush out and meet them with apparent delight and exultation.

Some species work side by side with their slaves However in one species (*Polyergus rufescens*, of Europe) the masters have depended on their slaves so long that they cannot build their own nests, or feed or care for their young, but have only retained the power of fighting to get more slaves. Huber tells of placing several of these slave holders by themselves where nearly all helplessly starved, al-

though there was plenty of food all around them. Then a slave was introduced, which at once set to work and made a nest and fed those still alive, thus saving from death its stupid masters."

Observations on Ants.

Observations on the habits of ants can be made by setting up artificial nests or formicaria.

A simple ant home or formicarium can be made by getting a flat tin box about one inch high and placing it on a support. The latter can be made of a piece of board with four vertical pieces for legs like a miniature table. A piece of glass large enough to cover two-thirds of the tin box should be placed on the box. This protects the nest, and at the same time enables one to see the working of the ants. Earth, but only a very small amount, should be placed in the nest, for if too much is put in, the ants will cover over their nest and hide their workings. The food should be placed in the open, light part of the nest. The whole apparatus should now be placed in a shallow meat dish filled with water. Part of the nest should be darkened so as to get the conditions as nearly as possible to the natural homes of ants in the ground or under a stone or log. To do this, many things could be done — a piece of wood could be placed over a corner of the glass, or a piece of cardboard could be used, but the least cumbersome is to paint one half, or a corner of the glass with dark paint or bitumen, and then the glass can be freely lifted when such is desired.

The next thing is to provide water, for this is very

necessary. Water can be placed in a shallow tin lid, or a piece of sponge kept moist, can be placed in the open, light part of the nest. In some cases it is advisable to have only the darkened part of the home covered, and to allow the rest of the box to be quite uncovered by glass.

The home is ready for the ants, and now an account of some actual observations will be given.

Observation on ants by Miss M. N. Brewster from "The Australian Naturalist."

Observation 1.—Ants: *Polyrhachis ammon*, or Golden Bodied Ant.

Brought from Heathcote in December.

The ants with larvæ and pupæ were placed in a tin box fixed to a stand which was put in a shallow enamelled dish full of water. The adults rushed about madly at first, scrambling over each other, many falling into the water, to be rescued and placed back again. Gradually their actions became milder as they explored every square centi-metre of their home, and in twenty minutes had settled down in their new surroundings. They then began to make the larvæ and pupæ comfortable, for during this period the latter had remained neglected.

They first seized the large pupæ containing queens or males and placed them in a corner, then they took some of the smaller pupæ (workers), and placed them close to some of the larger pupæ. They then seized the larvæ, and put them on some of the pupæ; they took some of the pupæ lying on the

outskirts of this living mass, and placed them close in, and higher.

Some moist loaf sugar was put in the box, and they began to get excited again as my hand went near, but they calmed down again and rushed for the sugar.

It was interesting to note that they left two of the large pupæ quite apart, and a few came to them every now and again, and walked over them, and sometimes stood on them, tapping gently with their antennæ. I presumed these pupæ were nearing the time of emergence into the imago or perfect ant.

It was noted that when one ant, which had got a severe soaking in the water, died, a worker seized the dead body, and took it to a far corner of the box.

Observation 2.—Ant *Camponotus nigriceps*.

District from which taken—Mosman.

Date—January.

I will not describe here the initiation of the ants into their new home, as this has been previously done. One can note, however, how various kinds of ants act very differently under similar conditions. Most of the ants I have tried, however, are much agitated when first placed in the home made for them.

Experiments with artificial feeding.

After having with success fed and reared wasps on Benger's and Allenbury's food, I tried to do similarly with the larvæ of ants,

I mixed a little Benger's food (half an egg cup full), and at first fed each individual by means of a finely cut straw, but when a number of hungry little babies had to be fed, it was surprising how long it took to satisfy their hunger. So I tried another plan. I took a number of pieces of wool. about 1 inch, a piece for each larva, and the ends of these pieces were dipped in the food. A strand of the wool was then placed near each larva in such a position as it could easily be sucked by the larva, should it want to do so. This acted very well, and the larvæ flourished on their artificial food, pupated, and later emerged as perfect ants.

Observations, Case 3.—Ant *Polyrhachis ammon.*

Locality Obtained—Paddington.

I collected ten winged ants (females), two workers, and ten pupæ. I placed them with another set of *Polyrhachis ammon.* During the first day of this addition to the nest, the ants were quiet; on the second day, I observed a bustling in the nest, and the workers seemed to be clearing it up—they were gathering up pupæ, and putting them into one corner, changing the position of the actual nest. They threw out a few little stones, sticks, and crumbs, that were in the nest, tossing them into the water below. During this time, the winged ants remained stationary, standing over some of the pupæ, and when the pupæ were moved they walked over to them, and seemed to be intent on sheltering them. If a winged ant wandered, it was promptly brought back again, and placed well among the

others. It appeared as if the workers had certain winged charges, for we observed for hours a number of the workers, and they always avoided certain winged ants, but went to their own special ones to feed them. But further observations need to be made, because there may be other reasons why certain individuals might be chosen.

A few days after this, a winged ant died, and a day later two workers and one winged ant emerged. I observed a winged ant take hold of a pupa, and tear one end open; it held on to the case, though I tried with a small stick to drive it away. It was then joined by another winged ant, which seemed to "talk" to it, and they both proceeded to rip open the case. One of these then left, while the remaining ant still held the case.

And now the ant in the case began to emerge. In 50 minutes from the first tearing open of the case, the head of the emerging ant appeared. The attendant ant appeared to be washing the face of the emerging one. It then ripped open the case further, after first having gone for another ant to aid it, by holding the case firm. Then slowly, one by one, the legs were drawn out, and the attendant ant appeared to wash each part as it was exposed. The emerging ant semed to give no assistance in this washing, and very little in emerging. At last it was pulled or helped out, and its wings looked like two lumps of jelly.

Now it began to work. It moved its jaws, and worked its limbs up and down, and in and out. At the same time one attendant ant worked at its wings.

At this period only one attendant ant remained. After twenty minutes' rest, the other ant returned, and the two worked at the wings. One held the newly-emerged ant, while the other pulled out the wings clear of their sticky covering (a kind of gummy mass).

Then came two more ants, and helped in the launching of the newly-emerged winged ant into life, and the whole emergence and cleaning took over six hours. I watched this till 2 a.m.

In May of another year I placed a small nest of *Polyrhachis ammon* in an inverted deep saucepan lid and placed the handle of the lid in a glass. Near to it was a similar nest of *Camponotus nigriceps*—the Sugar Ant, and there was interest in observing the differences in habits.

I placed a piece of wet sponge in each nest. The *Polyrhachis* ants sucked the water quite naturally, but the *Camponotus* would have none of it. They covered it over with sand, and made a nest of it. The sponge was taken out and washed and placed back again wet. The ants waited till it was partly dried, and began to cover it with sand, and as I left them in peace, they made a comfortable little home with rooms ready—the spaces in the sponge, and placed in them larvæ and pupæ.

Once when I was attending to these adjacent ant homes mentioned above, the lid in which the Camponotid ants were living was tipped up close to the Polyrhachis nest. In a few seconds the Camponotids had crossed over to the other, and there was a free fight between the two species. After vainly trying to separate them I promptly

submerged the lot in a basin of water. This served the purpose of separating most of them, and they were soon rescued and restored to their homes little the worse for their lively experience. However there were several victims.

Note that the ants have a habit of covering over with sand anything objectionable in the nest which they cannot remove, or which would be too troublesome to remove. If there is water spilt, and it does not dry quickly enough, they cover it up. They covered up various things such as chocolates and biscuit, if too much was put in.

O. HYMENOPTERA.

Fossore Wasps.

(*fossa* a ditch).

The term "*fossore*" is given because of the habit that many of these wasps have of digging in sand, They can be distinguished from the higher group of true wasps by the following characteristics:—

(1) The pronotum (part of the first segment of the thorax) is in the form of a collar-like ring at the back of the neck. (Plate 21, Fig. 9. b). The "pin waisted" mud dauber wasp shows this well because the collar is yellow and stands out clearly from the darker part of the thorax.

(2) The wings are not folded fanwise in repose, as is the case with true wasps, but held more or less horizontally over the body. (See Plate 22, Fig. 8.)

Fossore wasps differ from ants in having no nodes on the petiole or stalk of the abdomen.

These wasps differ from bees in having no branched hairs such as bees have to gather the pollen.

Fossore wasps are all solitary in habit.

Habits.—Fossores are predaceous, capturing insects and spiders which they sting in such a manner as to paralyse but not kill them, for these victims are the future food of their larvæ. However,

the victim is frequently killed when small or not very robust, and sometimes even at the first stinging, for wasps usually sting several times. They store the victims in their nests made either in sand, in stems of plants, in crevices, or in mud cells which they may build. Each particular species seems to have a preference for a certain food store; some capture spiders, others caterpillars, beetles, flies, cicadas, locusts. After storing their victims in the nest an egg is laid on one of them and the nest or cell is then closed. The larva hatches out, and is a tiny maggot which begins to feed on the food-store. It develops after several moults; it pupates and later on the adult emerges from its prison.

The adults feed on the nectar of flowers, on honey dew deposited by scales or lerps; but there is no return given by these insects for the sweets. Ants protect their sweet-yielding friends. The wasps simply enjoy the good provided.

A great deal of observation work needs to be done in getting accurate accounts of the life history of our fossores.

I. Family Scoliidæ.

The wasps of this family have a chink or notch between the first and second segments of the abdomen, and this is seen on the ventral or under side. (See Plate 21, Fig. 1. a). There are many wingless forms. The family can be divided into three sub-families:—

A. Sub-family Scoliides. Characteristics:— They are hairy wasps, the legs are stout; both sexes

are winged; the veins of the wings do not extend to the outer (distal) margin. (Plate 21, Fig. 5. a). They are parasitic on the larvæ of beetles. The eyes of Scoliids are usually notched.

B. **Sub-family Thynnides** (Plate 21, Figs. 7 and 8). Characteristics:—Males and females differ, the males are winged, the females wingless. Wings with veins extending to the outer margin. Similar in habits to the Scoliids. The abdomen is smooth looking with well defined rings. The adults of both these sub-families feed on the nectar of flowers.

C. **Sub-family Mutillides.** Characteristics:—These are ant-like forms, and often are associated with ants. The females are wingless, with the parts of the thorax closely soldered, forming one piece. (Plate 21, Fig. 6). Males differ in having the thoracic segments visible and are usually winged. They are parasitic in habit, parasitising other wasps and bees. The species *Mutilla rugicollis* is a large black wasp with white markings. These wasps are sometimes seen running on the ground or along tree trunks.

Sub-family Scoliides.

These wasps parasitise the grubs of the lamellicorn beetles (such beetle types being "king," "queen" or christmas beetle, and "washer-women beetles" of the children).

Of the common Scoliid wasps is the beautiful blue-black metallic wasp, *Discolia soror* (Plate 22, Figs. 10, 11 and 12), which we have observed for several years in late summer flying over the lawns

Fig1 Abdomen of Scoliid
a Chink

Fig2 Abdomen of Pompilid
a No chink

Fig3 Leg of Thynnid
a Single Spur

Fig4. Leg of Mutillid
a Double spur

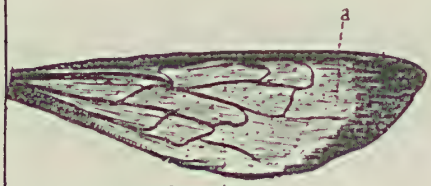


Fig5 Wing of Scoliid
a Margin with no veins

Fig6 Mutillid Wasp

Fig7 Wingless Female Thynnid

Fig8 Winged Male Thynnid

Fig 9. Part of Pompilid Wasp
(Pronotum & Tegulae in contact.)
a head. b Pronotum. c Tegula

Fig 10. Part of Sphegid Wasp
(Pronotum & Tegulae not in contact)
a - Tegulae
b. Pronotum

of the Botanic Gardens and at times alighting on the grass and burrowing through.

The female scoliid of some species seeks out the fat curled grubs of the lamellicorn beetles and lays an egg on the outside of the victim. To enable these wasps to hunt for the grubs in the ground, the body is furnished with a pair of strong digging legs with backward-directed bristles. The wasp-larva hatches out and feeds on the juices of the body, and increases in size until ready to pupate. It then spins a stout golden cocoon beside its victim which is now shrunken and lifeless. The adult emerges from its cocoon in the earth, and digs its way out, and flies off.

Another beautiful yellow and black scoliid is *Dielis 7. cincta,* which is parasitic, among other grubs, on the larva of the sugar cane lamellicorn beetle (*Lipidoderma albo-hirtum.*) The grubs of this beetle feed on the roots of the sugar cane so that the wasp in destroying some of these grubs is a little friend to the cane growers. We have caught the wasp on flowers of *Leptospermum* (Tea-tree), at Maroubra and Lindfield, and it is common along our coast and in Queensland. We have watched the blue metallic wasp, *Discolia soror,* feeding on the nectar of flowers such as marigolds, pincushions, etc., in the Botanic Gardens, and it was interesting to note that whereas the bee with its longer tongue could easily reach the nectar at the base of the flower tube, the *Discolia* had to push its head into the cluster of flowers in order to reach the feast. This wasp is also found feeding on the nectar of many native flowers.

Sub-family Thynnides (Plate 21, Figs. 7 and 8). The wasps of this sub-family are similar in habit to the scoliids, parasitising the larvæ of lamellicorn beetles; the adults feed on the nectar of flowers. We have caught the males of *Thynnus variabilis* and other thynnid wasps on the flowers of *Leptospermum*. There is a curious thynnid wasp known as the "blue ant" which is ant-like in appearance. It has a very powerful sting and a stout integument. Its name is *Diamma bicolor*, and it is the wingless female.

II. Family Pompilidæ.

Runners or Sand Wasps.

These wasps have strong running legs and can also fly well. Their habits are parasitic, for they hunt out victims, lay an egg on the outside of the body, after paralysing them, and then close up their sandy nest.

The wasp-baby feeds on the fluids of the body of the victim, whose skin it pierces with its jaws and sucks at the puncture.

The adult wasps are usually strong, free moving, and of black and orange colours.

Pompilid wasps have no chink between the 1st and 2nd segments of the abdomen. (Plate 21, Fig. 2.) The tegulæ and pronotum are in contact. (Plate 21, Fig. 9, b and c.)

III. Family Sphegidæ.

(Smaller Sand Wasps.)

This group of wasps is closely allied to the Pom-

pilids. The more advanced students can distinguish them by the following characteristic. In Sphegids the pronotum or collar is not in contact with the tegula (a little cup-like scale over the base of the fore wing). (See Plate 21, Fig. 10 a. b.). In Pompilids the pronotum and tegulæ are in contact, for the pronotum is prolonged backwards at the sides to meet the tegulæ.

Mr. Froggatt, in "Friendly Insects," thus sums up the habits of sand wasps (Pompilidæ and Sphegidæ). "In the sand wasps we have many large black and yellow long-legged hunting wasps, that flying over grass and herbage, capture small crickets, locusts, grasshoppers, and even large cicadas, which they drag or ride into the burrows they excavate in the sandy soil. Where these wasps are plentiful, they must keep down the number of small grass and plant-eating Orthoptera (locusts, grasshoppers, etc.)."

The Sphegids, which we will now consider, are all solitary in habit.

Genus Ammophila. This wasp makes tunnels in the ground. At the end of the tunnel is a little room, and it is here that the food store is placed. This species captures caterpillars; one only is needed if it is large, and several if small.

Mr. T. McCarthy has given the following account of *Ammophila suspiciosa* in the "Australian Naturalist": "During a recent visit to the Government Experimental Station at Hay nothing proved so interesting as the nest-making habits of the Thread Waisted Sand Digger *Ammophila suspiciosa*. The

wasps were in large numbers and from sunrise to sunset were continually on the move, scampering over the ground with wonderful activity in their endeavour to find a suitable locality to establish their nest. A slight elevation in the ground is the spot usually chosen by the wasps for their digging operations, and thus each hillock becomes a mass of independent nests, each carefully disguised by the wasps. No visible signs of the operation of the wasp therefore exist, save only a half finished tunnel, which some wasp had begun, and then, finding it unsuitable, had abandoned. Before starting to burrow the wasp carefully surveys the ground, and having chosen an apparently suitable site, begins to dig. After digging about half an inch deep she may suddenly cease operations and go in search of another site. This procedure is often repeated three or four times before the wasp finally decides the site for her nest. She then rapidly proceeds with the digging operations, using the strong mandibles for digging, and the legs for throwing back the finer material often two or three inches from the mouth of the burrow. When completed, the burrow is a simple shaft, with one enlarged cell at its termination, and in this cell is stored the caterpillar on which she lays an egg. As soon as the tunnel was completed the wasp emerged and after carefully circling round the tunnel entrance, set off at a run across the ground without attempting to fly. After travelling about 15ft from the tunnel she stopped at a green tuft of grass, and from it seized a green caterpillar about one inch in

length, in her mandibles, and straddling it, commenced the return journey. The caterpillar was quite limp, and had evidently been stung some time previously, as no attempts were made by the wasp to sting the caterpillar, which, beyond a slight twitching, was apparently lifeless when taken off the grass. The journey back to the burrow was accomplished without incident, and the caterpillar dropped just at the edge of the entrance. The wasp then descended the tunnel, probably to see that nothing had interfered during her absence; but soon after reappeared with her head facing the entrance, and seizing the caterpillar once more in her mandibles, backs down the burrow, dragging with her the lifeless body of the caterpillar. After about ten seconds she reappeared and proceeded at once to block up the tunnel entrance. At first with the aid of the legs she throws down a quantity of fine earth, ramming it down at intervals with the head, by short, sharp rushes. She then collects the large pellets of earth previously taken from the tunnel, and with the aid of her mandibles, carefully places them in position on the top of the finer earth so as to make a close, well packed filling. Larger pellets again are then used to fill up the burrow to the original level, and the top is then covered by a leaf, on top of which is placed a few scattered pellets in order to make it as nearly indistinguishable as possible. So the nest is completed, and the young wasp larva left to develop underground, the parent wasp apparently taking no further interest in the nest. Some three or four days later, I dug

up several of the wasp burrows, and in every case a single caterpillar only was found in the cell at the extremity of each burrow. To each caterpillar was attached a small wasp larva, the head only of which was inserted through the epidermis of the caterpillar, which was apparently dead, except for a slight twitching movement of the posterior extremity of the body."

The genus *Sphex* stores crickets and grasshoppers, etc. *Bembex* stores flies in a hole in the ground. There is usually a tunnel leading obliquely into a widened cavity at the inner end. The species *Exeirus lateritius* is very much like a pompilid wasp in general appearance. It is a large yellow and black wasp. It attacks cicadas, and after paralysing one by stinging it, the wasp drags it to its hole, usually straddling it. The hole is made in the sand, ready to receive the victim. An egg is laid on the ventral side of the cicada. The young wasp larva hatches out and feeds on the juices of its host by piercing a softer part of the integument.

We watched one of these wasps carrying a quite paralysed cicada to its hole which was made on a piece of flat, sandy land at the base of a gully. It was dragging the victim along on its back, straddling it.

Near the hole was a fairly large stone. We removed it to see if its removal would confuse the wasp. It did so, for it seemed quite worried, and flew round and round in a much more excited way than its ordinary method of approaching the hole.

Then we replaced this stone and on its return it went straight to the hole after a few preliminary circular flights.

The species **Pelopæus lætus** (Plate 22). This is one of the commonest mud daubers, and is frequently called a "hornet." It is also called the "pin-waisted mud dauber," and "spider wasp" because of its habit of catching spiders. It makes nests of varying size, usually of two rows of cells (Plate 22, Fig. 1). It works up the earth into little mud pellets and probably with the further aid of salivary secretion from the mouth. Each little wasp grub has a little mud cell about an inch in length for its temporary home. The mother wasp hunts for spiders; she seizes one, and after paralysing it, she straddles it until she is near the nest, when she carries it up to the cell. The number of spiders stored depends on their size. Usually the spiders are small to medium, and of the same species, a speckled type. It lays an egg on one of the spiders and then seals up the cell when sufficient food is stored. The little wasp grub hatches out in two or three days. It feeds about 10 to 15 days, and after a series of moults becomes a full-grown larva. (Plate 22, Fig. 2.) It then spins a brittle papery cocoon (Plate 22, Figs. 3 and 4), cutting off the excretion, and pupates within it, emerging as an adult about two weeks later. The adult is a yellow and black wasp with a conspicuous yellow ring-like collar or pronotum, and a very long slender petiole. (Plate 22, Figs. 7 a. and 8.) The pronotum and the tegulæ are not in contact. (Plate 21, Fig. 10.)

It is interesting to note the variations in habit

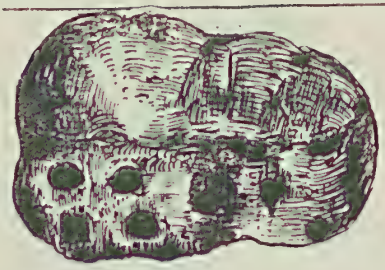


Fig 1 Mud nest

Fig 2 Larva

Fig 3. Larva with cocoon
a. Excretion

Fig 4 Pupa within Cocoon
a. Excretion

Fig 5 Cocoon within Mud cell
a Mudcell
b Cocoon

Fig 6 Remains of Spiders in Cell

Fig 7 Upper part of Sphegid
a Pronotum

Fig 8. Adult
a. Petiola

Fig 9. Cocoons of Parasitic fly found in cell.

Fig 10 Larva

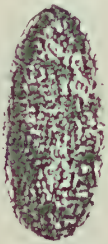


Fig 11. Cocoon

Fig 12 Adult, Discoln

(if any) in the lives of our wasps with those of other lands. Peckham noted that two-thirds of the spiders are killed at capture, most died in a week, and a few lived for nearly six weeks. He noted that the egg was laid almost invariably on the last spider, while Fabre records the egg being placed on the first captured spider.

Sometimes one finds an empty cell, or a cell packed with food store and no egg has been laid in it.

These wasps are often attacked by parasites. From a very large nest we bred out parasitic Tachinid flies, and one of the parasitic wasps.

In building the mud nest the mother wasp has a very busy time. As many as 40 to 50 loads of mud are carried in its mouth to form just one cell. The following are notes made from observations of a "pin waisted" wasp.

Notes on Pelopæus lætus.

A pretty yellow and black mud wasp (*Pelopæus lætus*) flew into the room and apparently began looking for a spot to build its nest. Finally the corner of the ceiling was selected in preference to many sites previously inspected. The wasp crawled over the surface several times, and appeared to be scratching it. This action may possibly have been to roughen the surface so that the mud would adhere more readily. The builder now flew away, but shortly returned with a rounded pellet of mud in its jaws. This was placed on the selected spot, and the front feet appeared to flatten it out to make it cover the greatest space. Many

pellets were treated in the same way till the foundation was finished. Then she placed several pellets and kneaded and worked at it till a hollow appeared. Now a little cylindrical cell began to take shape and form. The wall of this was completed, but the cavity was not closed in. The cell was over an inch in length, and the time occupied in building it was 1½ days.

The wasp was now absent for a longer period than usual, but on returning we noticed that the little mud ball was not the burden this time, but instead quite a large spider was held securely in its jaws. Four legs of the spider were arranged straight in front of the body, and parallel to it, and four similarly behind the body. The wasp came to the door of the cell, promptly pushed the spider in, and then crawled in herself to do the packing. The spider was not dead, but merely paralysed by the sting of its captor. Other spiders were brought and packed into the cell in a similar manner.

Now the reader may wonder what the wasp is going to do with these spiders. She does not eat them herself, but nature has taught her how to provide for her young, who do not happen to be like their mother in respect to diet.

When the first cell was fully provisioned, the wasp placed a tiny egg in it, then sealed it by placing a mud cap over the entrance.

The spiders were now in an almost airtight cavity, and would probably keep quite fresh until they had served their purpose.

Other cells were built and stored in the same way;

finally ten were completed. Being cylindrical, the cells only touched one another, leaving a little hollow between each. This hollow was filled up with mud until the whole presented a fairly even surface.

The ten cells were built in a fortnight. During the building a rather strange thing happened. We watched the wasp fly up to the nest with its load, and as it was starting out for another, we caught it with a net. Within a couple of hours, another wasp appeared and continued the work.

The story of the wasp is not finished, for later on out from each tiny egg placed in each separate cell came a legless grub, which immediately began to suck the juices from the bodies of the spiders. The food supply lasted till the grub was full grown, a period of from 10 to 15 days. Then inside the cell it formed an oval cocoon. In this it changed to the pupa, a white helpless looking object with three pairs of legs folded on the under surface of the body. The transformation continued, until one day the mud cap was pushed off from one cell and then another, and out from each struggled the fully developed slender bodied wasp.

In country districts in New South Wales every child calls this particular mud dauber a "hornet," and dreads it, fearing its sting, but it is not known to be agressive, or to sting people.

GROUP DIPLOPTERA.

(True Wasps.)

(Wings folded fanwise.)

These can be distinguished from the Fossores by several well marked characteristics.

(1) The wings are folded lengthwise like a fan, in repose. (Plate 23, Fig. 3.)

(2) The front part of the pro-thorax on the upper side, called the **pronotum**, is prolonged towards the back to form two angular side pieces. (Plate 23, Fig. 4, a.)

(3) The eyes are kidney shaped, not rounded. There is a notch just behind the antennæ. (Plate 23, Fig. 9.) This can be easily seen with a lens. However, the Scoliid-fossores have the notched eye.

(4) There is a marked absence of the numerous spines and spurs such as one finds in the fossores which burrow.

These true wasps can be divided into three groups —A. **Family Eumenidæ**, which has **a single spur** on the end of the tibia or shank, just near the tarsus, or foot. (Plate 23, Fig. 5.) The claws of the foot are toothed. (Plate 23, Fig. 7.)

B. **Family Vespidæ.** There are **two tibial spurs** on the middle legs. (Plate 23, Fig. 6, a.) The **claws** of the foot are **simple.** (Plate 23, Fig. 8, a.)

C. **Family Masaridæ.** A small family which have clubbed antennæ. These wasps have a narrow petiole and build nests in the form of a tunnel in the ground, or they make clay nests.

A.—Family Eumenidæ.

These wasps are a very interesting group, for they can be watched building their small or large nests of mud, and forming the little rooms in which they store caterpillars, etc. Their nests are found on the walls of buildings, under verandahs, on window ledges. Others are carpenters, cutting out nests from woody stems, and making little cells in them. They are all "solitary wasps," but social tendencies are perhaps indicated in their grouping together of cells and providing food, by hunting for it, for the baby grubs when they hatch in the closed cell.

One of the largest nests we have seen, about 8 inches across, was found under the roof of a verandah at Port Hacking. It was smooth and rounded, but of a general oblong shape, and there was an "entrance" in the form of a little funnel. It contained many strongly-made mud cells, separated by partitions quarter of an inch in thickness. The adults hatched out and were of the species *Abispa splendida*. This species can be distinguished by the following characteristics. It has a reddish orange angular pronotum; the wings are of the same colour but duller and with black tips. The first abdominal segment is black with a rim of orange-red on the lower edge. (Plate 23, Fig. 4.) The petiole is not so marked in this genus, though

Fig1 Diagram of Mudcell of Eumenid
(After Fabre)
a Egg b Caterpillars

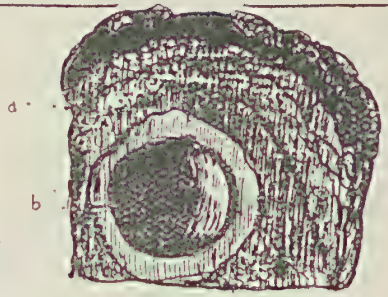


Fig2 Part of Mud Nest of Eumenid
a Layer of Mud b cell

Fig3 Folded Wings
a Tegula.

Fig4 Eumenid (*Abispa splendida*)
a. Angular Pronotum.

Fig5 Tibia of Middle
Leg of Eumenid Wasp
a Single Spur
b Tibia

Fig6. Tibia of Middle
Leg of Vespid Wasp
a Double spurs.
b. Tibia

Fig7. Foot of Eumenid
a Toothed Claws.

Fig8 Foot of Vespid
a. Simple Claws.

Fig9. Eye of
True Wasp.

Fig10 Larva of Eumenid (*Synagris*)
(After Rabbaud
a. Food Paste.

it can be seen when the wasp curls its body round.

Six adults emerged and four pupæ were found in four other cells, so that there were ten cells in the nest. They were large and oval in shape. At the narrower end there was a little circular cap or lid. The excrement was shut off at the broader end of the cell by the larva spinning a floor of a silken membrane. This membrane was continued all round the cell and adhered to the wall like wall-paper, but one could tear it off like a strip of cloth. Within the cell was the naked pupa, and the last moult-skin of the larva. It is interesting to notice the difference in this eumenid wasp to that of the fossore mud-dauber *Pelopaeus*. In the latter the cocoon covering is not attached to the wall, but is a brittle papery structure immediately round the pupa, so that when the cell is broken the naked pupa is hidden by the cocoon, whereas in *Abispa*, the eumenid wasp, when the cell was broken across the naked pupa was at once seen, and the cell had the appearance of a bare little room. In a mass of the excrement in one of the cells, seen when one tore off the "floor-lining" at the larger end, there was a cocoon of a fly which was shut out with the excrement. The fly was dead within the cocoon.

The cells of the nest were very strongly built and of larger pellicles of earth than is seen in many nests; one would expect this from the large size of the wasp. Also on the outer side the cells were protected by three or four layers of mud (Plate 23, Fig. 2, a, b), so that this solid part of the nest had a

stratified appearance when it was broken across, and was about half an inch thick. There was a beautifully formed entrance in the shape of a funnel.

The genus *Eumenes* is another of the mason wasps, and builds mud cells. Fabre records a curious habit of some species of these wasps, that of suspending an egg from a slender thread which is fastened to the roof of the cell (Plate 23, Fig. 1, a.) Thus it is thought by some that the egg is protected from any movement on the part of the caterpillars which are stored in the cell; for many of the eumenid wasps do not seem able to sting their victims so effectually as do the fossores. The little baby-wasp grub hatches out and stretches down to the nearest caterpillar. It pupates within its cocoon, and later on, the adult, a gay black and orange wasp, emerges to carry on the life history of its kind, unless it becomes a victim of insect enemies, human collectors, or other accidents.

Another Australian genus is *Odynerus*. Froggatt says: "This genus contains a number of small thick-set wasps, that make clay nests of various shapes; sometimes very delicate in structure, forming a finger-shaped row of clay cells or rounded cup-shaped chambers; while some species make use of a hole in the wood or wall and simply coat it over with clay. Australia is rich in the species, some of which have a very wide range."

These nests frequently contain parasites. In one nest we found the cocoon of two different species of parasitic flies and of a parasitic wasp.

There is another mud-dauber or mason wasp which has the very bad habit of filling every key-hole of the outer doors of houses near the bush. An experiment was tried by a resident of Epping, of boring several holes in a slab of wood, and so enabling the wasp to find a home, which caused every satisfaction to it, and was decidedly better for the inmates of the house.

Some of the smaller eumenid red and black wasps build smaller and less compact houses which appear to be, in some cases, just carelessly put together and easily broken.

There is another Eumenid wasp of the genus *Synagris* of whose habits we will quote in detail, for they form a link with the more strictly social wasps (Family Vespidæ). We quote observations made by E. Roubaud in "The Natural History of the Solitary Wasps of the Genus *Synagris*," published in Smithsonian Report for 1910. The observations were made in the Congo Region, Africa.

"The wasp, *Synagris sicheliana*, lays an egg in its cell of earth. Then without haste, after having guarded it for some time, it commences to collect a small provision of caterpillars for the moment of hatching. When the larva has commenced to feed, the *Synagris* continues the provisioning, but in a slow and regular manner, taking care to furnish its larva with a little more food than is necessary for the day. It is a progressive provisioning from day to day, which gives the wasp the necessary leisure to guard the larva and watch its growth."

"The caterpillars lie in the earthen cell. The

egg is deposited beside them and is not fixed to the wall of the nest by a suspensory thread (made use of by wasps of genera *Odynerus* and *Eumenes*), although this thread still exists attached to one end of the egg. The egg is not fixed to the prey as in the case of the fossore wasps. It is deposited in the bottom of the cell and the female watches for the hatching in order to begin the provisioning. This is therefore a habit of social wasps. The wasp does not wall up its cell after laying the egg. It remains there itself and guards the egg—its head directed downwards, thus preventing the access of parasites. On the other hand it begins provisioning at such a time as will enable the young larva, after hatching, to be certain to find its food. The provisioning which then takes place regularly and in proportion suitable to the size of the larva, permits the *Synagris* to watch the growth of its young."

Roubaud also describes another species of *Synagris* which shows still further advance in social habits, getting close to the Social wasps, insomuch as the mother hunts for caterpillars, but instead of giving them to the larva to feed on, she chews them up into a paste and places it on the lower surface of the thorax of the larva (Plate 23, Fig. 10), in such a position as to enable it to bend its head and take in the food, "a little mass of a green colour, and of semi-fluid constituency, which the larva ate greedily." The mother-wasp hunts nearly all day at short intervals, for the baby grub is very hungry. At night she stands at the door of

the cell and guards her offspring. When the larva is full grown she closes up the cell and begins another one adjoining the latest formed.

B.—Family Vespidæ.

(Plate 24.)

These wasps can be distinguished from the other groups of true wasps by habit and by the presence of two tibial claws on the middle legs, and by the simple claws of the foot. (Plate 23, Figs. 6 and 8). These wasps are usually of a duller colour than most wasps. They are predaceous and feed their young on masticated spiders, etc. The adults feed on nectar of flowers, on juices of fruits when bruised by birds. There is an angular pronotum (Plate 24, Fig. 6 a). The genus *Vespa* or "yellow jacket," or hornet is absent as far as is known in Australia. These wasps build paper nests, but the cells are usually enclosed in a papery envelope so that the cells are hidden. We have in Australia, the paper nest wasps of the genera *Polistes* and *Icaria*.

Polistes makes a nest on the branches of trees, on ledges of verandahs and window sills. Some species make papery nests under logs and these are usually not stalked.

The genus *Icaria* is another Australian Vespid which differs from *Polistes* in having a long narrow linear nest, the base of it of several cells in depth, and the outer end tapering to a one-celled row. The wasp is smaller also than *Polistes*, with a more noticeable petiole.

Life History of the Paper Nest Wasp.—These wasps are social in habit, that is, they have a home common to a community. There are three castes (a) males, (b) females, (c) workers. The latter are females which do not lay eggs but take charge of the home. The nest and the community last but for one year. In the autumn the males and females emerge. The males have no sting with which the queens and workers are armed. Also the males have seven segments in the abdomen, while the others have six. The colouring of the three castes is similar, so that it is hard to distinguish a stingless male from the others, hence he is protected. The females or queens are usually larger than the workers. In the autumn the males and workers die, and the fertilised queens winter over, hiding in cracks in logs, trees, under stones. When spring time comes the queen comes out from her winter shelter and flies to a tree or post, and begins to tear away pieces of the wood in shreds and converts it into a kind of paste, probably with the aid of the salivary juices of the mouth. Thus the wood is reduced to the "paper" of which the nest is made. The mother, or queen of *Polistes tasmaniensis*, begins the nest by forming a patch of sticky, dark material, and then a stout, black, very slender stalk, which is smooth and often shining as if covered with a kind of varnish. It is placed so that the nest is held downwards, thus a roof is formed by the bases of the cells. (See Plate 24, Fig. 7). This roof is sometimes covered with a smooth encrusting secretion which seems to make it

water-tight, and as the "roof" slopes downwards the water runs quickly off. The mother-wasps make several cells of paper, the openings directed downwards, and in each cell near to the middle of it she fastens a little elliptic egg with a short stalk. (Plate 24, Fig. 2, a.) One can see the tiny baby grub gradually form in the egg, for it is translucent in most cases. When the little larvæ are hatched there is a very strenuous time for the mother. Each larva has to be fed, and she has to hunt for spiders and masticate them, and feed her children. As she approaches the cell the little grub raises its head to receive the food, and we observed some of the larger ones pushing their heads right out of the cells just as little hungry birds do. The larva (Plate 24, Fig. 3) has a kind of pad at the end of the abdomen and it seems to be able to fasten itself to the cell by means of this, as it hangs head downwards. It moults several times and the moult-skins are pushed down to the bottom of the cell along with excretion. When ready to pupate (Plate 24, Figs. 4 and 5), the larva builds a loose web at the mouth of the cup. In the earlier life of the nest only workers hatch out, and they now come to help the mother-wasp. They take control of the home, enlarging and cleaning cells, making new ones, hunting for spiders, and feeding the babies.

We observed a nest of *Polistes Tasmaniensis* on a tree during a whole season. Near by was a hedge of olive trees, and when the young berries were out (about the size of small peas) we noticed that these

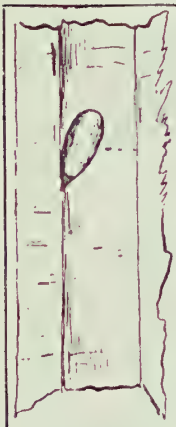


Fig 1. Cell cut open
a Egg

Fig 2. Egg.
(Embryo developing)
a. Stalk.

Fig 3. Larva

Fig 4. Pupa

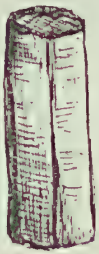


Fig 5. Pupal cell
closed

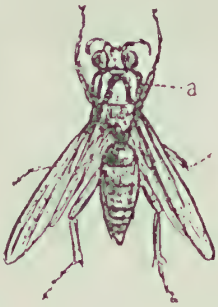


Fig 6 Adult
a. Angular Pronotum.

Fig 7 Paper nest

Fig 8. Two cells of leaf cutting bee.
a cell

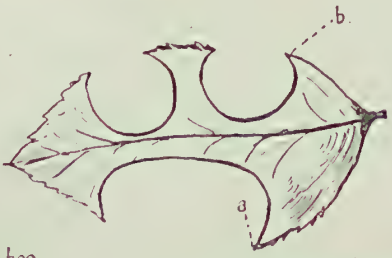


Fig 9. Rose leaf with pieces cut out
by Leaf cutting bee
a. Side piece
b. Top piece
for cell.

wasps went to the trees and cut off berries and carried them to the nest—one wasp carrying one berry. As the wasp alighted on the nest with a berry another home worker came forward and seized the other end of the berry and the two stood and worked at it till they had severed it with their jaws. Then another wasp came forward to the wasps which had half a berry and they further reduced it till it finally disappeared. They did not go then and feed the baby grubs, so that it is probable that they were feeding themselves and also sharing their fruit with a wasp busy at home.

During several weeks' heavy rain the nest was quite unharmed. It was protected partly by leaves, but the rain was very heavy, yet it seemed to run off quickly from the smooth sloping surface. We observed during the season the feeding of the wasp-grubs, the enlarging of cells, the emergence of adults from the pupal chamber aided by the workers, and the cleaning out of such cells. When the adult emerges a couple of workers aid it, and stroke it with their antennæ. It is pale at first but soon gets the normal brown colour of the worker and takes its place among its sisters, foraging, cleaning and building.

These wasps seem to have adapted themselves to a mixed diet, for though normally they feed their larvæ on masticated spiders, the same larvæ have been reared in the later end of their life on vegetarian diet.

Also the adults feed on nectar of flowers, on juices of fruits. Yet we have observed workers

seize the larvæ in a nest, tear them and devour them. We saw two workers drag a very large larva out of its cell and cut it in two, each taking a half, and only for the cruelty of their doings, it was almost comical to see them stand with thorax almost vertical, hold part of the victim with their forelegs, and tear their food bit by bit and devour it. They reminded one of little urchins picking a bone.

These wasps do not sting unless molested, yet when they build low down on a verandah or bush they are likely to become a nuisance, as they will attack anyone rashly approaching too closely to their nest. When the nest is broken down they are most persistent in coming back and building in the same spot. They have a powerful sting.

Observations made on the Life History of the Paper-Nest Wasp.

(*Polistes tasmaniensis.*)

A small nest of this wasp was found at Mosman on 12th February, and the few workers resting on it were captured by means of the net, at the expense of a few stings, and the nest was removed.

There were 20 cells in it made of a papery greyish white material. Four of the cells contained each one egg; in the others there were larvæ in various stages of development, one in each cell. The remaining cells contained each a pupa.

As the adult wasps found on the nest had been placed in the killing bottle, an effort was made to

feed the larvæ with Benger's food. A thread was dipped into the liquid, and then held near the mouth of the larva, and it took the food eagerly. After that, each larva flourished on three meals a day of Benger's food. They put their heads up eagerly as soon as they felt the touch of the thread or of a straw from a millet broom, which was used later. When doing this, they looked like little hungry birds stretching their necks right out of the cells.

We will give a detailed description of one of these larvæ, which was found in the nest. After taking food for about a week, we noticed it was very restless, stretching itself out of the cell, and when food was applied to its mouth, it rejected it.

Once after a few convulsive movements, it turned its head right under its body, and remained in that position for two minutes. After this rest, it stretched itself agan, and began to move its head all around the edge of the cell with a tapping movement. We then saw it was building up its pupal chamber. Its head was moving from side to side, and as it built up the sides of its cell, it turned gradually and completely around it. When the wall was finished, the length of the cell had been increased to $\frac{1}{8}$ of an inch.

It now turned its attention to the building of the cap or roof of its pupal chamber, and it began to work a little below the top edge of the cell, working upwards in a circle till the inner roof was completed. The operation of wall building had commenced at 9.30 p.m., and finished at 11 p.m., and the roof was complete at 12.45 a.m.

One interesting fact was, that one of the larvæ split its cell wall as it increased in size, and we pasted a piece of paper at the side to repair it, and it was quite content, increased the length of the wall, and made the cap at top, and pupated. But another larva was not so easily satisfied. The side of the cell split, and we tried to patch it with gummed paper. It started to pupate by increasing the length of the cell, but when it had finished this, instead of turning its attention to the cap or roof of its pupal cell, it began to repair the side of its cell, which had split. We left it at this work, and the next morning expected to see it safely in its pupal home, but it seemed to be vainly endeavouring to make the cap, and could not, so we concluded that it had not sufficient thread to do so, as it had used it in the repairing of the side of the cell. So we placed a small piece of cotton wool over the top of the cell, but it would have none of it, and pushed it off.

We then placed a narrow gelatine tube over the top of the cell, but it did not alter its uncomfortable position of hanging out of the cell. We then took the larva out of its cell, and placed it in the tube with a little cotton wool at the top to allow the air through. The larva died.

We then took a large healthy larva not quite ready for pupation, and placed it in a tube, feeding it on the juice of crushed spiders—part of its natural diet; but this larva also died, not seeming to flourish except in its natural cell, or perhaps being injured in the removal from its cell.

But the most interesting part of this nest was, that not only did the adult wasps hatch out from the larvæ fed partly by artificial means, but from two of the eggs tiny wasp maggots hatched out, and were fed on Benger's food, and flourished; they increased in size, pupated and completed the whole life history, taking in one case, 49 days, in the other 54 days, thus proving that wasps can be artificially fed and reared from the egg.

Further observations were made of a much larger nest, one measuring 8 inches across. We fixed this nest up in a circular sweet-jar of clear glass, with diameter of about 6 inches. The nest had to be cut in halves: one half was placed on floor of the jar, with mouth upwards, and the other we placed in its natural down-turned position, suspended from the top of the jar by means of picture wire which was wound round the jar, and the nest was tied on to it. We fed this large family for some days, and the feeding took from 1½ hours to 2 hours. At last some adults emerged from the pupal chambers, which were there when the nest was obtained. We then placed mosquito net on the top of the jar to keep the workers in. Slices of pear were placed in the jar, and the adults eagerly partook of them, and at once began to feed the larvæ. Adults kept hatching out daily till 20 workers were in the jar.

Now a curious thing happened. They began to attack the larvæ in the nest on the floor of the jar, and kill them, dragging them out of the cells, and in some cases devouring them, and probably using them to feed the more fortunate larvæ in

the upper normal half of the nest. Then they used the paper of the lower nest to work up and enlarge the cells of the growing larvæ above. The new clean rim could be seen on the renovated cells. They lived for months in this nest, feeding the larvæ and working about the nest. At last some died, and we set free the remainder of adults, putting the larvæ into spirits to preserve them. (Taken from the "Australian Naturalist" Observations by M. N. Brewster.)

GROUP ANTHROPHILA. (Bees.)

Families: A. Andrenidæ, Short-tongued Bees.

B. Apidæ, Long-tongued Bees.

Bees can be distinguished from other hymenopterous insects by (a) the presence of plumose hairs, *i.e.*, hairs that are branched (See Plate 26, Figs. 1 and 4). These hairs enable the bee to carry the pollen easily as it passes in and out of the flowers. (b) The modification of the legs for special purposes, particularly the hind pair where the tibia and the first tarsal joint are broadened and modified for the collecting and the carrying of the pollen. The tibia on the hind leg is the "pollen basket." (Plate 26, Figs 4 and 6.)

The mouth of the bee is specially formed to enable it to suck up honey or nectar from the flowers. Mandibles are present and are used for removing wax and kneading it. According to the mouth structure bees are divided into two broad Groups: A. **Andrenidæ,** or short-tongued bees; B. **Apidæ,** or long-tongued bees.

A. **Family Andrenidæ.** The tongue of Andrenids is short and broad. These bees are solitary in habit and many make nests in the ground. In some species the mother-bees make their nests close to each other to form a little village or township. Each

little home has an entrance tunnel with several side passages running from it. The mother bee makes a cell in each side passage, and the main entrance of the tunnel is free.

The genus *Halictus* goes still further towards social habits. Several mother-bees build a common home. There is a main entrance or tunnel in the sand which may be a foot long. Then each mother builds her own side passage and constructs a series of cells in each of which she packs pollen and honey, and an egg, and then seals them up. Andrenids do not store honey in special cells, for their homes last only one season. After laying the egg and sealing up the cell the mother bothers no further about her offspring. Some andrenids are very lazy and do not make a nest and store food. They lay eggs in the cells of some working andrenid and simply have a lazy time among the flowers. The larva of the lazy-bee, or **inquiline**, eats the food supply of the rightful owner of the nest. Hence these inquilines are often called "cuckoos," and they have not the legs developed for the carrying of pollen.

Prosopis is a genus of Australian andrenid. These bees are of a black or metallic blue colour with yellow markings. *Halictus* is also found in Australia with several other genera. We found that a species of Andrenid bee cross-pollinates the flowers of the lance-leafed geebung (*Persoonia*).

Family Apidæ.

These are the long-tongued bees whose mouth has been described in the general characteristics of the

Order Hymenoptera (Plate 25, Fig. 4). This sucking mouth is specially adapted for getting the nectar from fairly long flowers such as salvia, sunflowers, cosmos, and many of our native "pea flowers." Of course bees can visit open shallow flowers such as *Leptospermum* and some of the *Eucalyptus*. We have seen bees on the shallow green flowers of ivy, sucking off the whitish secretion on the flower. These bees play a very important part in the pollination of flowers, for even solitary bees have to gather a large quantity of pollen and honey to be placed in each cell, and hive bees must gather an enormous quantity of pollen and honey to provide the food supplies of the hive. Hence these bees are constant dependable visitors to certain flowers — *ex.* : *Persoonia* (geebung). Some flowers are specially adapted for the visitation of bees, having mechanical devices to keep out small insects such as ants, and larger useless insects such as butterflies. Such flowers are snapdragon and many of our bush "pea-flowers." On the other hand hive bees are in turn unwelcome guests to many of our native flowers, such as the red spider plant (*Grevillea punicea*) and "bread and meat" (*Darwinia*), for they do not cross-pollinate these flowers which depend on birds to do so.

There are two large groups of these long-tongued bees :—

(1) **Solitary Bees.** (2) **Social Bees.**

(1) **Solitary bees.** These bees make various kinds of nests, and may be popularly termed "carpenter bees," "mason-bees," "leaf-cutting bees," accord-

ing to their habits. We observed the nest of a mason bee which was made up of ten cells. Two cells had nothing in them at all. The others had larvæ or pupæ. The cells are made of little pellets of mud which are beautifully welded together to form a firm little home. The cells are not so strong as those of many mud-dauber or mason wasps, but they are firm. On examining the cells with young larvæ present, we found at one end of the cell a supply of "bee-bread," honey and pollen mixed to form a paste. With a lens we could see the masses of white pollen on the yellowish honey. On examining the pollen microscopically we found it to be that of some myrtaceous plant such as *Eucalyptus*, or bottle-brush (*Callistemon*) or *Leptospermum*. Larvæ could be seen in all stages of growth in the different cells. There were three pupæ, and from one of these hatched a ruby-wasp (a parasite). In one cell we found two larvæ, a large yellow one similar to the bee larvæ of most of the cells, and a smaller paler grub which was that of a ruby-wasp which was feeding on the larva of the mason-bee. In another cell we found the pupa of a ruby-wasp in its cocoon, and at the base of the pupal cell could be seen the waste material shut out, consisting of a moult skin and excretion. (Plate 16, Fig. 11.) On several of the larvæ we found a mite, a tiny little creature, just able to be seen with the naked eye—it was of similar colour to the larva and was parasitic on it. There were other little cream insects, very active, crawling all over the cell and they were probably

scavengers; they were about 2 m.m. long. We bred out two ruby-wasps from this nest. (Plate 16, Fig. 10.)

The Carpenter Bees.—One of our Australian carpenters is called *Xylocopa*: it is a large, sturdy-looking bee, which is found chiefly in Northern New South Wales and Queensland.

Another genus is *Lestis*, which may be found boring in the stems of the grass tree (*Xanthorrhoea*), in which it makes a number of little cells where it stores a paste of honey and pollen.

Genus *Podalirius*, or "blue-banded bees," which are so often seen on the flowers of the bush and in gardens. When flying from flower to flower to get honey it has a quick jerky motion, but when near the flower it hovers over it a little, moving its wings in such a manner that they appear motionless. We watched hive bees (*Apis mellifica*), and several bees of species *Podalirius* visiting the flowers of the large golden "pea-flower" (*Gompholobium*), and it was very interesting to see how much better the native blue-banded bee opened the flower in its search after nectar than the hive-bee. As it alighted on the flower, the flower spread open wide, brushing the pollen on to the bee. The hive bee opened it also but much less effectively. It has been recorded that this blue-banded bee visits the *Bouvardia*, but does not aid in the pollination, for it nips the flower just where the pollen boxes of the flowers are placed, about midway in the tube, and it

takes the pollen and spoils the flowers. Such visitors are practically "thieves."

Leaf-Cutting Bees.—Genus *Megachile*: These are an interesting group, and they often cut their material from the rose plants in the garden. They make a series of thimble-shaped cells, of larger pieces of the leaf for the sides of the cells, and shorter, rounded pieces of the leaf for the ends. They store "bee-bread," and lay an egg in each cell, which is then sealed up. They make their nests in crevices in the trunks of trees, in deserted nests of carpenter bees, or in the old burrows of grubs of wood-boring beetles. Fabre thus describes the work of making the nest: "She makes a strong barricade composed of the only materials used in the "Leaf-cutters' Guild." Fragments of leaves are piled up in no particular order, but in sufficient quantities as to make a serious obstacle to enemies from the inner end of the nest. Immediately after the protective barrier comes a row of cells which vary considerably in number. Strings of about a dozen are rare, and the most frequent consist of five or six. No less variation is shown in the number of pieces formed to make a cell: pieces of two kinds, some oval ones forming the "honey pot": others the round ones, forming the lid. Though all are cut on the pattern of an ellipse, they are not equal in dimensions and come under two categories. The larger outside ones are each of them almost one-third the circumference of the cell, and overlap one another slightly. The lower end bends into a concave curve to form the bottom of the bag. Those

inside, which are considerably smaller, increase the thickness of the sides and fill up the gaps left by the first" . . . . For scissors she has her mandibles, for compasses, producing now an oval, anon a circle, she has her eye and the pivot of her body. The pieces cut out are made into thimble-like wallets destined to contain honey and the egg."

Observations on the Leaf-Cutting Bees.

We made some very interesting observations at Clarence Siding, Blue Mountains, in January. At the end of a long stone verandah were a number of rose bushes and two clumps of honeysuckle; near by were apple, plum, hazel-nut, and quince trees. There were numbers of the dark leaf-cutting bees busily working all day among the leaves of all these trees till 7 p.m. at night.

Some of the smaller branches of the rose bushes had their leaves reduced to shreds by the too-frequent visits of these workers. We watched them approach the bushes and they were rather hard to please in their choice of leaves, for they alighted here and there before making the final selection. Occasionally they would make a slit and then leave the leaf. There were numerous leaves which showed that the leaf-cutter had begun its operation and for some reason or other had left its work.

Most of the bees worked from the edge of the leaf and round to the right, but occasionally we saw one cut from right to left.

The more common shape cut out of the leaf was the elongate side-pieces for the cell of its nest.

(See Plate 24, Figs, 8 and 9.) The cutting was beautifully neat, and the head of the insect moved around rapidly and smoothly. In watching the bee cut one of these larger pieces one would think it was going to cut a smaller circle, but on reaching the half circle, it works along, enlarging the piece, when it curves around again, cutting the piece off. The piece is then slightly bent from the outer edges and carried away with ease under the body and held by the legs. Some of the bees almost stood on their heads in the cutting process, but the majority were just slightly inclined. If one placed one's head close to the bee while it was cutting, the noise of the working mandibles could be heard quite distinctly, like the "click, click" of a pair of scissors.

An amusing incident occurred. One of the bees in severing a rather larger piece than the average, cut into a leaf vein, for on setting out with its booty it was jerked back by a thread of tissue from the vein and had to pull several times before it finally broke the thread and flew off in triumph or in anger.

Most of the leaves cut into showed that the bees selected any leaf for either side pieces or top pieces for the cells, but occasionally we saw leaves with a series of small circular holes only. Pieces of fading yellow leaves of roses were also used. The rose leaves and leaves of hazel-nut plants were evidently the favourites, though the leaves of honeysuckle, plum, and apple were also used.

The hum of these bees is quite distinct from

that of the steady hum of the hive bee. It is more jerky, and resembles the angry sound of the hive bee when it has been disturbed. As the hive bees were gathering nectar and pollen from the honeysuckle flowers near by, we could distinctly recognise the difference between the two. We found tough leaves of the waratah cut by these bees. This leaf-cutter is a black and white banded bee, the white bands being thick fringes of white hairs on the dorsal side of the abdomen. Tufts of hairs are present at the sides of the head and body; fringes occur on the under side of the abdomen, and these were laden with pollen in the specimen examined.

The mandibles are very strong; they are broader than those of the hive-bee; they have four stout teeth, and they interlock and slightly overlap. The legs have dense fringes of white hairs, and on the front leg is a comb for cleaning the antennæ. The back legs are fitted for gathering pollen, and in addition have two very stout tibial spurs which probably aid in holding the piece of leaf when it is being carried off. On visiting Clarence Siding the next year it was found that the bees had been cutting hard at the young leaves of wistaria and honeysuckle, but especially at the leaves of the hazel nut, so that it seems that no preference is given to any one of the chosen plants, but it visits the leaves of those with the greatest number of fresh young leaves. (Observations on Leaf-cutting Bees by M. N. Brewster—"Australian Naturalist.")

THE HIVE BEE.

(*Apis mellifica.*)

This is an introduced insect from Europe.

Bees have reached a very high standard of development, and they show wonderful social instincts. The hive is worked on the principle of the best for the community as a whole.

Like the vespid social wasps, there are 3 castes: (a) males or "drones," (b) females or queens, (c) workers. The latter do not lay eggs though they are females; they take charge of the hive and direct the affairs therein. Each worker bee has some particular task to perform. Some are nurse bees, and their work is to feed and care for the young bee-grubs or larvæ. The nurses are the workers which have just emerged from the pupal cells; they act as nurses for about three weeks and have special glands which enable them to specially feed the "baby bees." Later they become foragers, going out to seek for pollen or nectar. Most of the workers seek flower honey or nectar, and in doing so they get dusted with pollen, and so cause cross pollination. Such honey-flowers, which also yield abundant pollen, are sunflower, cosmos, pumpkin-flower, and most of our bush pea-flowers. For the hive bee has extended its visitations to the flowers of the bush; in some cases it can cause cross-pollin-

ation by carrying the pollen from one flower to another, such flowers being Hakea (needle bush), many of the short-tubed Epacrids, and flowers of grass tree spike. But in other cases the bees visit the flowers and steal the nectar without rendering the service of cross-pollination in return —in such cases the hive bees are "thieves," or unwelcome guests. Some of the flowers which the bees do not benefit are the red spider plant (*Grevillea punicea*), bread and meat (*Darwinia*). Other flowers are visited by the bees just for pollen alone, example, many wattles (*Acacia*), some of the rib grasses (*Plantago*).

The bee has a special stomach or "crop" in which it carries the flower-honey or nectar, and it can regurgitate it at will, either to feed a comrade, or to put it into the store cells of the hive.

For the gathering and carrying of pollen the bee is wonderfully fitted with external organs by the modification of the legs. We will speak of this later on.

Other bees are water-carriers; they fly to any moist place such as a shallow pool, or a dripping tap; or to the little hollows left in the ground, where water from a tap accumulates. We have observed dozens at a time around such places on a very hot day. Also it is not uncommon to see bees sucking up the water left on the blades of grass after the lawn has been watered.

Other bees search out substances in flowers which they use to make wax, by a curious process in the body.

Fig 1 Larva

Fig 3 Brood cells.
a Queen cell

Fig 2. Pupa

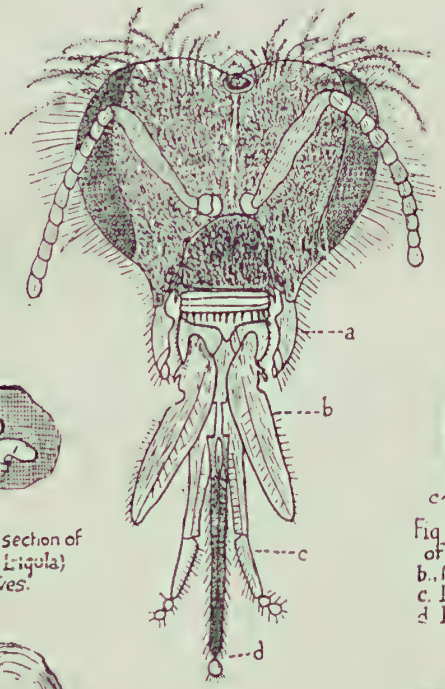


Fig 4. Proboscis of Bee.
a. Mandibles.
b. Maxillae.
c. Labial palps
d. Liqula or Tonque.

Fig 6. Cross. section of
Tonque. (Ligula)
a. Grooves.

Fig 5 Cross section
of mouth.
b., Maxillae
c. Labial Palps
d Liqula

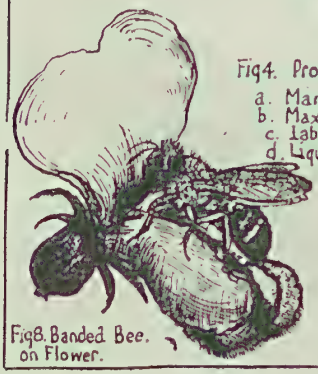


Fig 8. Banded Bee.
on Flower.

Fig 7. Abdomen of Bee.
a. Wax plates.

Thus we see that the workers are always busy, only stopping for a little refreshment, and then flying off again to continue their work.

The workers that stay at home, besides tending the bee-babies, also keep the hive clean. They also watch and tend the queen-mother, for she is never left a moment, but is attended by a retinue of workers, who feed her and stroke her and look after her generally.

The hive is well-ventilated. A kind of "natural electric fan" is made by certain bees being "told off" to move their wings, which are kept in constant motion for some time.

Now we will consider the "nurseries" or brood-cells. These are situated in the warmest part of the hive. The nurse-bees feed and look after the little bee-grubs, going from cell to cell, feeding them with "bee-bread" (this is a mixture of pollen and honey.) The little grubs have a certain number of moults and gradually increase in size. As they grow older, the food is varied. More honey and less pollen is given till at last they are fed on honey alone. The food given to the bee-larvæ has a great deal of influence on the nature of the adult. A queen can be produced from an ordinary worker-larva by feeding it on richer food; in this case the cell of the chosen worker-larva has also to be enlarged because queen bees are larger than workers.

When the adults are hatched and leave the cells, the latter are cleaned out to be ready for the queen to deposit an egg in each.

Life History of a Bee.

The cells of the comb are about one fifth of an inch in diameter. When the egg hatches the larva is a helpless grub or bee-maggot, for it is legless. The food is placed in the cell with the larva, and it partially floats in it. Nurse bees go from cell to cell supplying the food, for they have thousands of babies to feed. The brood cells or nurseries are in the warmest corner of the hive. The larva moults six times, and the moult skins are pushed down to the bottom of the cell. On pupating it reverses its position in the cell, and turns out from its stomach a certain amount of accumulated indigestible food. Then with its last larval skin, it shuts off the old larval skins and the food-waste, by making a "floor-covering" of the skin.

It now turns back to its old position with its head towards the opening of its cell. It spins a porous covering across the top of the cell, shuts itself in and eventually pupates. Meanwhile a nurse-bee finishes the work by spinning an additional external cap to the cell. Air can penetrate both caps and thus the pupa can breathe. When the adult emerges, it is paler in colour than the normal worker. It now becomes a nurse-bee, and acts as such for about three weeks. It has special glands present to enable it to work up the food of the bee-babies so that they can digest it. At the end of three weeks these nurse-bees become foragers; and the glands lose their functions. They now gather pollen and flower-honey, bring it home

and put it in cells, some of which are set apart for pollen, others for honey. Note that flower-honey is not the same as honey in the comb. The former is changed by some re-action within the bee's body into the "golden honey" of commerce.

The Queen and the Drones.—The queen-bee has a longer body than the worker; she has a powerful sting. The queen and worker have six segments in the abdomen; the male or drone has seven. The male or drone has no sting, for he does not forage for nectar or pollen, neither does he defend the hive. Drones merely hang about the hive doing nothing but sip the honey and bask in the sunshine. However, should food be scarce the drones are turned out of the hive, and often killed by the workers.

Drones have no specialised legs such as the workers have.

After the marriage flight the queen returns to preside over the old hive (note the old queen leads the swarm of bees away to form a new hive). She lays about 2,000 to 3,000 eggs a day, so that she needs to be very well nourished. The eggs are of 2 kinds (a) fertilised eggs (b) unfertilised eggs which produce males. The fertilised eggs produce workers, and these different eggs seem to be laid at will.

When swarming takes place the old queen leads the departing swarm, and sets up a new kingdom, where the cells are quickly made by the workers with wax which they have manufactured out of materials obtained from plants.

We will now consider the **worker**—her body is wonderfully formed, certain parts being modified in such a way as to form organs to enable her to perform her various duties. We have described her mouth in the chapter on Hymenoptera. This mouth (Plate 25 Fig. 4) enables her to carry any reasonable bulk of honey or nectar. The mandibles enable her to tear and knead the wax into whatever form is required, such as cells of the comb. The body is covered with hairs which catch the pollen easily. The legs (Plate 26) are specially fitted for pollen-gathering. The usual parts of an insect's leg are present—the coxa or hip; trochanter; thigh or femur; shank or tibia; followed by a five-jointed tarsus or foot, the first joint of which is always very much larger than the other tarsal joints. The last tarsal joint carries two larger claws with smaller claws or bristles, and also "touch" hairs which are sensitive to touch. The foot is beautifully fitted for walking on either smooth or rough surfaces. When the bees are making wax they cling together forming festoons of their bodies, and they do this by means of their claws. The claws of the hind legs of each bee are turned upwards to form a "hanger," while those of the front feet of the next bee hook on to them. They hang together until at last the plates of wax exude between the segments of the under side of the abdomen (Plate 25, Fig. 7a.). This wax is gathered and worked up to form new wax cells.

Should a bee be walking on a smooth surface the claws are turned up out of the way, and a pad

which lies between the claws is brought into action. The bee can spread out or contract the pad at will. On the lower surface of the pad are numbers of tiny pores, through which a sticky secretion oozes which just enables the foot to hold on to a smooth surface, without sticking to it.

The legs are most curiously fitted up. The **first** pair (Plate 26, Figs. 1 and 2) are furnished with a comb and brushes. These can be seen with a lens, and can be beautifully seen with the low power of the microscope. The comb (Plate 26, Figs. 1 and 2) is situated on the first tarsal joint of the foot. It is semi-circular and has a number of closely-fitting teeth. Over this comb fits a little "door," called the **velum** (Plate 26, Fig. 1, b, c, and Fig. 2), which is fastened to the tibia or shank. This comb is used to clean the antennæ. The antenna is placed in the comb, the velum fits over and the antenna is then drawn through. On the edge of the enlarged tarsal joint which carries the comb is a set of stout spines, and these form a brush to remove pollen, etc., from the eyes. (Plate 26, Fig. 2, d.) Smaller tufts of hairs occur on the legs, which brush off finer particles, or grains left by the larger brushes. On all the legs are specially long and branched hairs called "gathering hairs," which catch the pollen. These are well developed on the thigh, (Plate 26, Figs. 1 and 4).

The middle legs carry a spur or spine on the tibia. This is used to lever out the pollen when it is be-

ing removed from the pollen basket. (Plate 26, Fig. 3.)

The **hind legs** carry the **pollen basket** (Plate 26, Figs. 4, 5, 6.) The tibia forms this basket—it is a flat surface with stout hairs on the edges which stand well up to keep in the pollen. On the under side of the pollen basket are a few stiff hairs, but the upper surface which carries the pollen is smooth.

When one sees a bee in a pumpkin flower, or on a sunflower or cosmos, one can understand how necessary these cleaning instruments are, for the bee is often covered all over with pollen. On reaching home the middle legs lever out the pollen masses in the baskets, and each mass is passed on to the front legs and then placed in the cell. Note how bees often rest on a plant and clean off the pollen from its head and body and place it in its pollen basket.

The **sting** of the worker is situated at the end of the abdomen and consists of poison darts with poison ducts connected with poison bags. There is a wonderful mechanism for sending the poison down the ducts to run into the wound made by the points of the darts. Only queens and workers have stings. The queen uses her sting to attack other queens which may hatch out in the hive. Should two queens hatch out, they usually fight till one is demolished. When a new queen has safely returned to the hive, she may go round and destroy any queen pupæ which may be in the hive, and the workers in this case do not interfere.

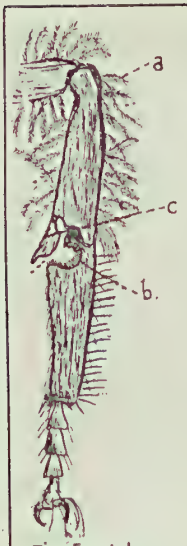


Fig 1. Front Leg.
a. Gathering hairs
b. Comb
c. Flap.

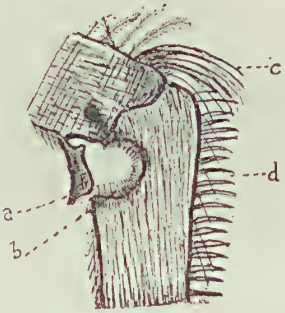


Fig 2. Comb enlarged
a. Flap, b. comb
c. Fine brush.
d. coarse brush.

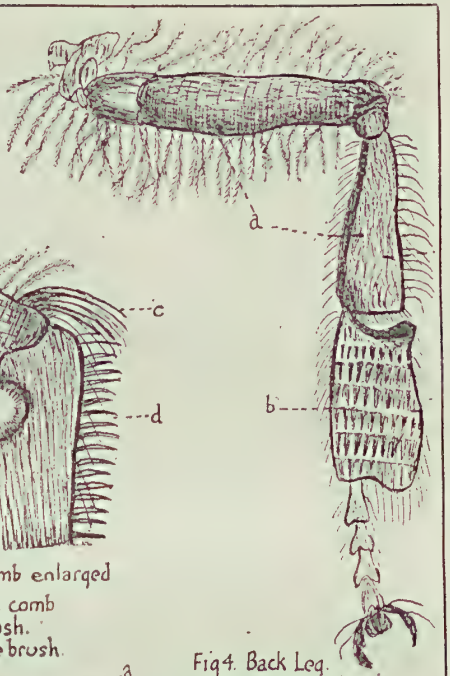


Fig 4. Back Leg.
a. Pollen basket (Tibia
b. Enlarged joint of foot.

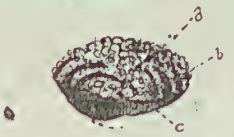


Fig 5. Cross section of basket.
a. Pollen.
b Hairs
c. Basket.

Fig 3. Middle Leg.
a Spine.

Fig 7. Head of Female
a. Ocelli

Fig 6. Back Leg with basket full of Pollen.

When the swarming is to take place, and should the young queen emerge before the old queen leaves, the workers have to protect the new queen from the old one.

The workers, besides manufacturing wax and honey from the nectar of flowers, and "bee bread" from mixed pollen and honey, also prepare a resinous material with which they line the nest, and fill in cracks and smooth roughnesses in the hive.

The Native Honey Bee (*Trigona*) builds a nest of wax cells, but it is not so finished nor so well regulated as that of the hive bee.

The nest is made in a hollow tree, often with only a small opening. The one we observed had an opening whose diameter was about 1½ inches. This tree was seen at Killara, and was struck by lightning; it was cut down and on being sawn for firewood the nest was discovered and observed at leisure. The tree trunk was about a foot in diameter: the roughness of the hollow in the tree was smoothed by a deposition of wax which formed a lining to the hole. The hollow extended on either side of the opening, and the honey cells were at either end—innermost. These cells were smooth, irregularly rounded, and about the size of marbles. Most of them were joined together to form a solid mass, and some on the outer side of the mass were joined to the walls by long slender stalks of wax (see Plate 27, Fig. 1), varying from ¼ to 1½ins. in length. Some of the larger honey cells were a little isolated and joined to the main mass by stalks of wax, but probably they formed the foundation cells for others

Fig 1. Honey cells

Fig 2 Brood cells

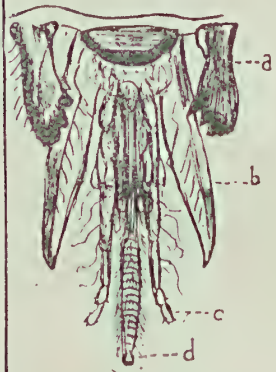


Fig 3. Sucking Mouth.
a. Mandibles
b. Maxillae.
c. Labial palps.
d. Ligula.

Fig 4. Larva

Fig 5 Pupa

Fig 6. Adult

Fig 7. Part of Front Leg.
a. comb.
b. flap.

Fig 8 Back Leg.
a. Tibia (Pollen Basket) b Tarsal Joint

Fig 9. Magnified Gathering hair.

to be built near them to make a more solid mass. At one end of the nest there was a mass of deserted honey cells of dark colour, and hardened considerably. The fresh honey cells were of a reddish-brown colour, not the light colour of the hive cells. The honey-cells of the *Trigona* were much larger than those of the hive bee, while the brood cells were much smaller. The latter were in the central part of the nest we examined, while at one inner end was a patch of deserted honey cells, much hardened, and at the other end and extending from the central brood cells were the fresh honey cells laden with honey, which had a distinct flavour, but was not unpleasant to taste. The brood-cells (Plate 27, Fig. 2) were much more regularly arranged than the honey-cells, and were in distinct rows of 2 to 3 layers, and the layers of cells could be pulled apart in sheets. The majority of these cells contained pupæ, the cells being more or less polygonal with the pressure of adjacent cells; but instead of having a horizontal cap of wax, the "lids" of the cells were curved upwards tapering broadly, thus resembling rather the cocoons of ruby wasps, only that they were made of wax instead of silky material.

We opened some of the pupal cells and the pupa (Plate 27, Fig. 5) was quite cream with the exception of the large reddish compound eyes, and the three pink ocelli or single eyes between them.

Numbers of tiny adults were swarming over the brood-cells, and these were very inactive and slow in movement. Not one flew off even when we put a few out in the sunshine, but the weather was

cold and bleak and had been such for some days.

The **Adult** (Plate 27, Fig. 6) when examined with a lens showed the presence of thick brushes of hair on the head, thorax, and legs, and there was a broad patch of grey hairs on each side of the thorax.

The **hind leg** (Plate 27, Fig. 8) is most noticeable owing to the enlargement of the tibia. It is rather smooth and polished looking, with a shallow depression on the outer side, and it is thickly fringed with hairs—thicker on the outer edge. On examining with the microscope these hairs on the outer margin were seen to be branched (plumose), but the branches are simple and the hairs are, on the whole, stiff and regular, not slender and thread-like with compound branches as one sees in the "gathering hairs" of the hive bee. The plumed hairs of *Trigona* are also irregular in having the branches developed more on one side; on the other they are often just small projections. (See Plate 27, Fig. 9). The majority of the hairs on the inner side of the pollen-basket were simple, unbranched and stiff. The first tarsal joint is also much enlarged to form an instrument to aid in gathering and carrying the pollen. On the under side it is thickly clothed with stiff hairs, and on the lower margin it has a distinct row of thick, straight spines like a straight comb. A noticeable feature was the absence of the gathering hairs on the femur or thigh, they were confined to the tibia in the specimens we examined.

The second pair of legs was the smallest, and here, too, the tibia was thickly clothed with gathering hairs on the outer margin, and on the inner

side were stiff hairs, a few being feebly branched at the apex.

We could see no trace of the decided "spur" which is used to lever out the pollen from the "basket" of the hive bee, but one stiff hair seemed to stand out more clearly in some cases.

The front legs are very similar to those of the hive bee. On the first enlarged and elongated tarsal joint is a beautiful "comb," which is used to clean the antennæ. The comb is semi-circular, and a complete encircled space is formed by means of a "door" which is attached to the tibia. This door or **velum** is in the form of a hard curved chitinous bar which ends in two or three short spines at the free end, and which spreads out on the inner side into a broad, thin chitinous area, the whole being more or less curved triangular in shape seen from the side. (See Plate 27, Fig. 7, and a and b).

The mouth, too is very similar to that of the hive bee—the mandibles are toothed but broad. (Plate 27, Fig. 3.)

If a few of these bees are soaked in a weak potash solution for a couple of days, and then examined with the microscope these structures can be plainly seen.

Pollen from flowers was found in masses on the gathering hairs, on the pollen basket, and on the hairs of the enlarged tarsal joint of many of these bees. We examined these grains and found some to belong to the flowers of family Myrtaceæ (*Eucalyptus*), bottle brushes (*Callistemon*), also elliptical grains suggestive of the family Rutaceæ

(*Boronia, Eriostemon*). There were some rounded grains which we could not identify.

It was interesting to note that these grains were, on the whole, quite in separate masses. Occasionally we got a few isolated triangular myrtaceous grains mixed in with the elliptical grains.

The blacks call these bees sugar-bags. It is recorded in "Across Australia," by Baldwin Spencer and F. J. Gillen, Vol. II., page 467: "The whereabouts of the 'sugar-bags' is determined by placing the ear against likely-looking trunks or boughs, when the low hum of the bees at work inside can be heard, or sometimes by actually watching a bee entering a small hole in the bough. During the rainy season and in very cold weather the natives say that the bees close the entrance to the nest with mud. If, as sometimes happens, the nest is attacked by predatory ants, a number of bees block the opening with their own bodies. When once the 'sugar-bag' has been located it is then chopped out. The comb is quite irregular in shape, varying in quantity, of course, in different hives. The cells are like little rounded balls, the largest about a quarter of an inch in diameter, some of them containing honey and some pollen and sticky stuff not yet made into honey. The third kind is much smaller and contains eggs, larvæ and pupæ. The whole mass, except the small cells (though of course many of them are included accidentally) is scooped into a piece of bark. Hundreds of bees get mixed up with the honey and the pollen, but the natives do not mind this and eat the whole of it with relish. So far as the honey is concerned it is excellent."

ORDER COLEOPTERA.

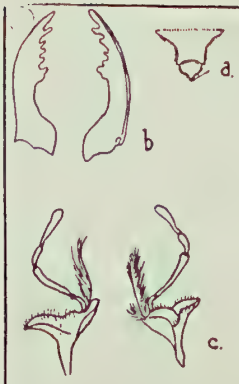
(Beetles.)

These insects have the front pair of wings modified to form hard shields or cover wings without veins (hence the name of the order: *Coleos*, a sheath, and *pteron*, a wing).

Characteristics: (1) The hardness of the integument: hence beetles preserve well for collections, and in some cases are set in gold and silver for necklaces or brooches. The Buprestids are sometimes used in this way.

(2) **Wings:** The first pair of wings are shell-like and are termed **elytra** or cover wings (Plate 28, Fig. 1b). They do not cross one another but fit together along the middle of the back, thus in repose forming a veritable armour-plate for the body. The second pair of "flying wings" is folded and tucked away under the elytra when the insect is not in flight. (Plate 28, Fig. 1.) In some cases the flying wings are absent and then the elytra are frequently soldered to form one sheath: this is seen in some ground beetles (Plate 30, Fig. 2) and in some weevils.

(3) The **thorax.** The prothorax (Plate 28, Fig. 4a) is usually large and very free; from the dorsal side only the prothorax is seen, and it is often called the thorax by beginners. On examining the under



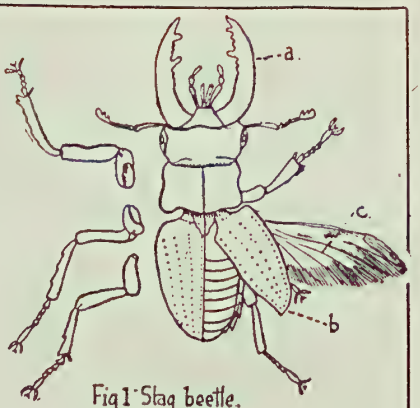


Fig 1. Stag beetle.
a. Mandibles.
b. Cover wing
c. Flying wing.

Fig 2. Mouth
a. Labrum
b. Mandibles
c. First Maxillae
d. Labium.

Fig 3. Life History of Scarab (Scitala Pruinosa)
a. Larva b Pupa c: Adult.

Fig 4. Scarab (*Anoplognathus*)
a. Prothorax

Fig 5. Antenna. plates closed.

Fig 6. Antenna. plates open.

side of the beetle one can distinguish the three thoracic segments by the position of the legs. The mesothorax is small, its chief function is to support the elytra. The metathorax is large and is firmly attached both to the mesothorax and to the abdomen. The strength of the mesothorax is necessary, as the hind coxæ are often very strong and large, and need support. These large coxæ may conceal the upper segments of the ventral or under side of the abdomen. The latter often remains membranous and gives greater freedom in movement. Usually only five segments can be seen on the ventral side of the abdomen.

(4) The **mouth** of beetles (Plate 28, Fig. 2) is a typical biting and chewing type: mandibles are usually prominent, the maxillæ or outer jaws are present with maxillary palps: the labium with labial palps forming a solid plate.

Life History: The **larva** is a grub with 3 pairs of horny legs. This can be well seen in the wire worm (Plate 31. Fig. 10), and in the fat curled grub of scarab beetles, which is found in the soil. (Plate 28. Fig. 3, a.) In some larvæ of beetles the legs are either quite absent, or are represented by little swellings. This is so in many of the boring grubs, such as are found in firewood and in tree stems: example, buprestids and longicorns. The presence and the strength of the legs depend on the habits of the grub.

The **pupa** (Plate 28, Fig. 3, b.) is in most cases "naked," and the appendages are free. When the adult beetle emerges, it leaves behind

this shell with the legs, mouth parts, and wing pads clearly seen and free. It thus differs from the pupal shell of moths and butterflies. These "mummy-like" beetle-pupæ can be seen sometimes in holes in firewood and in the ground.

The **adult** has been described. Thus we see that the metamorphosis is **perfect** or abrupt.

Habits.—Beetles are found almost everywhere, but because most of them are night-feeders and live in seclusion under logs, in the ground, in trees, etc., and because beetles do not fly freely in the day time, one does not realise their number. They are found on leaves, in tree trunks, in roots, under bark, in rotting wood, under stones, in the ground, in excrement of animals, in decaying animals, in grains and in flour. Others feed on skins, museum specimens, opium, tobacco and leather.

Many of them are important economically, for though some prey on larvæ of pests, and are thus useful in getting rid of many obnoxious insects, others are serious pests, boring into wood, attacking roots of orchard trees, sugar cane, etc. Others feed on cereals and ruin the crops of the growers.

LAMELLICORN BEETLES.

(Plated Horns.)

(Plates 28 and 29.)

This Group includes three families:—

(1) **Family Scarabæidæ** (Scarabs).

(2) **Family Lucanidæ** (Stag Beetles).

(3) **Family Passalidæ** (Passalids).

General Characteristics of Lamellicorns: (1) The terminal joints of the antennæ are enlarged to form lamellæ or little plates (Plate 28, Figs. 5 and 6).

(b) The larva is a thick, creamy, curled grub found in the ground, in rotting wood, or under logs (Plate 28, Fig. 3, a.)

(c) The larva and adult are vegetable feeders, hence the mandibles are fitted for biting and are not enlarged to seize prey.

Characteristics of Lamellicorn Beetles.

(1) **Scarabs:** The antennæ with 3 terminal plates which can be co-adapted accurately to form a lamellate knob. (Plate 28, Fig. 5). The tip of the abdomen (pygidium or tail) is usually exposed. They are mostly thick, heavy, compact beetles, and this form suggests free movement, for such a shape would be of little use for getting in cracks or under bark, etc. These beetles are usually found on plants or in the earth. The larvæ feed on the roots of grasses and cereals. They

also attack the roots of strawberry plants. The larvæ of scarabs move over a wider range than those of passalids and stags, hence the horny legs are strong in the scarabs.

Most of the scarabs on pupating simply make a hollowed-out cavern in the soil and pupate within it: examples, *Anoplognathus* and *Scitala pruinosa*. However we found definite mud cocoons of the fiddler scarab (*Eupoecila*) and some of the pellets of excretion were found adhering to the outer part of the cocoons. (Plate 29, Fig. 1, b.)

(2) **Passalids** (Plate 29, Figs. 5 and 6).—The antennæ have 4 or 5 plates which can only be co-adapted when curled up. Usually the plates are fairly far apart, and hence stand well out. The tip of the abdomen is not exposed. Passalids are oblong-looking beetles with strongly marked ridges and grooves down the elytra. We have captured as many as sixteen under a large log which had been undisturbed for years. There were larvæ, too—the fat curled grubs—in all stages of development. The larvæ of passalids have usually but four legs, the hind pair being but short processes. The common genus is *Aulacocyclus*.

(3) **Lucanids** or **Stags** (Plate 29, Figs. 7 and 8).—These are longer than most scarabs and can readily be distinguished by the very large mandibles held straight in front of the head, also by having the tip of the abdomen covered, and by having longer antennæ whose plates are not co-adapted to form a club. The mandibles of the male are larger than those of the female, and in some species are of ex-

Fig 1. Life history of Fiddler Scarab.
a. Larva b Pupa in Cocoon c Adult.

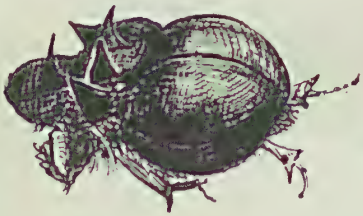


Fig 2 Digging Scarab

Fig 3 Antenna of Digging Scarab.

Fig 4 Digging Leg.

Fig 5 Passalid Beetle . Fig 6 Antenna of same

Fig 7 Stag beetle.
b Mandible

Fig 8.
Antenna
of same.

traordinary size. They are thought to be chiefly ornamental in order to attract the female.

The larvæ are found in rotten wood, under logs, etc. The legs are shorter than those of the scarab larvæ. The genus *Lamprima* is the common metallic green or greenish-blue stag beetle and is very beautiful.

Types of Scarabs.—To this family belongs the sacred beetle of the Egyptians, *Ateuchus sacer*; also the cockchafers, some of which are such pests in Europe. Our commonest cockchafer is the genus *Anoplognathus*, which includes the "king beetle," the "queen beetle," and the "washerwoman" of the children. These are all handsome beetles. *Anoplognathus viridaeneus*, or king beetle, is a large, beautiful metallic green scarab. *A. analis* (Plate 28, Fig. 4) (named *analis* from a tuft of hairs at the anal end of the body), is the "queen" beetle, and this and *A. porosus* (referring to the "pores" or punctures on the elytra) are pests in some years on the leaves of many eucalyptus. The "washerwoman" (*A. porosus*) in spite of its name, has very beautiful opalescent tints on its buff-coloured elytra, and we have seen these on the grey leaves of a eucalyptus and the colouring of the beetle blended very well with the leaves. We have seen these scarab beetles reduce the leaves of a young eucalyptus sapling to mere threads where the main veins were left bare. One tree overhangs the rock pools on the edge of one of our harbour bays, and every year dozens of queen beetles are drowned in the

salt water of the rock pools, as they fall off into the water.

Rose Chafers.—These are mostly easily recognised by the shortening of the sides of the wing covers like a "cut-away coat." In some of these scarabs the lamellæ or plates of the antennæ are very flat and long. In living beetles the plates can be seen clearly—they usually close together on the death of the beetle. The plates are especially large in some species of the humming rose chafer, *Diaphonia*, the brownish-yellow beetle with black marking which buzzes into the garden and bumps up against one in the hot summer day. There is always a certain amount of clumsy recklessness suggested to us in the flight of this beetle.

Another common bush rose chafer is the genus *Cacochroa*, which is very common in flowers; it varies from black to light brown in colour and has very short wing-covers.

"The Fiddler Beetle" (Plate 29, Fig. 1) (*Eupoecila australiasiae*) belongs to this group, and is a very gay individual with pale green markings over its deep brown coat. In September we found at Tuggerah Lakes a number of the cocoons of these beetles in the base of a living but hollowed gum tree. There were nearly twenty of the mud cocoons. They looked very curious, somewhat like the mud cells of the mud-dauber wasp, only they were not attached firmly to each other. The larvæ in forming the cocoon had worked in numerous little excretion pellets on the outside of the cocoon, making the cell look like a mud-dauber's large cell. We gently opened the cocoons

and all contained larvæ except one, and it had a dead fiddler scarab in it. We removed the cocoons and put them in a box. On November 20 we examined the box and found that all had pupated except two, and the beetles had even emerged from all but one. We wanted to preserve the beetles, so put several in methylated spirits (having no killing bottle at hand); we also put the remaining pupa in the spirits. For about an hour after leaving them in the spirits they seemed dead; we placed two beetles in a box along with the pupa. In a few days the two beetles were very much alive, but all that remained of the. pupa was a mere shell. (This note was recorded in the *Australian Naturalist*, Sydney, April, 1917, by M. N. Brewster.)

The Digger Scarabs (Plate 29, Figs, 2, 3, and 4) ("dung beetles" or sexton beetles). The mother digger makes a hole in dung and inserts an egg in it; the larva feeds on the dung, getting sustenance therefrom. Most of these beetles differ from the other scarabs in having thick rounded bodies and elytra. Some of them are almost as round as a ball on the upper surface. The head is fitted for digging and shovelling, for it is broad with a projecting rim at the outer edge which acts as a shovel; the legs also are fitted for digging. The common genus of this type is *Onthophagus* (Plate 29, Fig. 2) They are dark beetles, and in most species the male has additional spines or ornamental projections; in one genus, *Bolboceras*, the head of the male is prolonged into a long horizontal proboscis, whereas the female's head is a normal type. In

this group are the "burying beetles." They bury the carcases of birds and small animals. Froggatt records the process of burying of a wallaby by many of the beetles of one species of *Onthophagus*. They remove the earth below the carcase and so lower it in the earth. Many writers have given interesting accounts of the work of these clever little diggers. Fabre tells us of some of the European "dung beetles," which roll the dung into little balls, and insert an egg or two in the ball. They roll the ball along and hide it away from the dung patch. Sometimes one or two beetles aid in the rolling of the larger dung balls, and he records that some of the lazy beetles will snatch away the dung ball made by the owner and roll it off after laying its own egg in it. It does this when the owner is digging a hole to bury the dung-ball. The idea of rolling the ball and hiding it is probably partly to secure sufficient food for the baby grubs and at the same time to hide it away from the large dung-mass which is more conpicuous, and hence more liable to attack from enemies. Fabre also records that the clever little mother beetle does not make the ball in haphazard fashion, but has the more delicate part placed close to the egg so that the little baby grub will have a digestible meal ready for it. The coarser and more indigestible food is farther away ready for it when it has grown bigger and stronger.

Another group is the "honey scarabs," which love the flowers of the bush and are found in great numbers on flowers of *Leptospermum*

(tea tree), some of the *Kunzeas* and others. It is a light brown colour usually, while some individuals are of darker colour. The best known of this group is Genus *Phyllotocus*.

Another scarab is the sugar cane beetle of Queensland, a very serious pest, for the grubs feed on the roots of sugar cane and destroy the plants. This pest is called *Lepidoderma albohirtum*. The word "Lepidoderma" means scaly skin, and the upper portion is clothed with greyish scales; albohirtum means "white hairs."

On the whole, the Lamellicorns are pests.

Observations on Lamellicorn Beetles.

We found an interesting life history in a garden when the soil was being dug up with a spade.

Several lamellicorn larvæ were seen and one pupa. Then in a little mud-lined cave about two inches across was all that remained of a scarab-grub—only a shrivelled empty skin. Alongside this was a reddish-brown silken cocoon, elliptical in shape, tapering towards one end. Here was a tragedy! This brown cocoon enclosed the pupa of a wasp—a fossore or digger wasp. The adult mother-wasp had laid an egg on the body of the lamellicorn grub and out of this egg hatched a little baby wasp-maggot, which, with its sharp jaws, pierced a tiny hole in the skin of the big grub. Here the wasp-maggot sucked the juices of the beetle grub, and grew and flourished till at last, after several moults, it was ready to pupate. It then had exhausted all the food within the body of its victim, which

was now an empty shell. It detached itself and began to spin its pretty silken pupal home and gradually disappeared within it. The outer threads of the cocoon were loose but the inner ones were firmer and more closely woven. Here it rested in the ground till the time came for the adult wasp to appear. It then pushed off a little lid at one end of its silken home, and out of this brown cocoon came a handsome blue-black metallic wasp. By means of its front legs and mandibles it makes its way out of the earth and flies about in the sunshine, visiting flowers, and burying its head among the nectar-yielding flowers of marigold, etc., of our gardens, or on *Eucalyptus* and *Leptospermum* (tea tree) of our bush.

The wasp parasite is *Discolia* (Plate 22, Figs. 10, 11, 12.)

Observations on a Small Brown Scarab.

(*Scitala pruinosa.*)

Late in September, whilst digging in our garden we came across scores of the larvæ of this scarab. They were, as a rule, from 6 to 9 inches below the surface of the ground, most of them being snugly coiled up in tiny cavities in the soil which they had apparently made by a wriggling movement. These grubs measured about 1¾ inches; they were of a greyish white colour with head and jaws of brownish red. Three pairs of long, horny legs on the first three segments of the body; in fact, it was a typical lamellicorn larva.

About six weeks after the first time we saw the

larvæ, we noted that the grubs were fewer, but, instead, we found numerous pupæ within these tiny caverns.

Still continuing our gardening in November, about the middle of the month we found the adults. We noted the first beetle groping about in the earth as if to find a way to daylight. It was about half an inch long, light brown in colour with darker head. For the next week or two we noticed these beetles continuously in the earth. By the side of the garden plot was a young gum tree, and one evening, just at dusk, we heard the sound as of a swarm of bees, and on investigating, found that the gum tree was surrounded by a miniature cloud of beetles, which finally settled upon it. Night after night these beetles came, about the same time, and they stayed there nearly all night, taking their departure some time before 4.30 a.m. For exactly three weeks this night visitation took place, and as a result our tree was completely denuded of its pretty young shoots. On the 18th December we noted that they came in fewer numbers, and hovered round the tree in an uncertain manner. Now and again one would alight but fly up again. For about 15 minutes this uncertainty prevailed; and then they flew off in the opposite direction to that in which they came. A few stray ones were found on the tree the following evening, but after that not one was ever seen.

CARABS AND TENEBRIONIDS.

Family Carabidæ and Family Tenebrionidæ.

We take these two types together, not because they are closely related, but in many cases they resemble each other in outward form and are often confused by beginners.

We will give a summary of the chief differences in the outward form of these two groups.

Carabs (Plate 30, Fig. 1).

(1) Antennæ usually filamentous, that is, thread-like, and tapering to a more or less fine point. (Plate 30, Fig. 1, b.)

(2) There are five joints on all the feet (Plate 30, Fig. 1, a.): The fifth joint carries the claw. The joints are usually longer than in tenebrionids.

(3) The legs are highly developed for running —they are strong and long, for carabs are predaceous, that is, they hunt other insects and devour them.

Tenebrionids (Plate 30, Figs. 2 and 5).

(1) Antennæ are thread-like in the lower part, but instead of tapering at the tip, they become thicker and form a rather narrow club, in some cases. (Plate 30, Fig. 5a).

(2) There are 5 joints on the front pair of legs:

Fig 1 Carab
a 5 Joints on foot
b Antenna thread like

Fig 2. Piedish Tenebrio

Fig 3. Larva of Carab

Fig 4 Back foot of Tenebrio
(4 Joints)

Fig 5. Tenebrio
(Antennae clubbed)

Fig 6. Rove beetle

Fig 7 Larva of
Rove beetle.

Fig 8 Soldier beetle
(Malacodermid)

Fig 9 Glow worm
female beetle.

but the back legs have only 4 joints. (Plate 30. Fig. 4). The joints are usually shorter than those of carabs and so are more closely packed.

(3) The legs are not particularly fitted for running. These beetles are chiefly scavengers feeding on decaying vegetable and animal matter.

(4) The mouth parts are suitable for chewing; the mandibles are not specially formed to seize prey.

There is one tenebrionid pest; it is the "flour grub." The mother insect lays her eggs in flour, etc., and the grub feeds on it and spins a loose silken cocoon in the flour, bran, pollard, or chaff. These beetles, *Tenebrio molitor*, are common in stables, mills, and fowls' food. The larvæ may pupate in corners of the boxes in which the foods are kept.

Life History of Tenebrionids.—The eggs are laid under logs, in cracks in the soil, in crevices in logs, and in bark near the ground. The larva hatches out. It is an elongate narrow grub with thick integument. The legs and jaws are not so strong as are those of the carab larva. There is usually only one process at the end of the body. This probably aids in locomotion. It feeds on vegetable matter chiefly, and is a scavenger.

It pupates under logs or similar places. The adults are also scavengers, usually feeding at night. A few are carnivorous.

We have noticed three groups of tenebrionids:

(a) **Black** or dark tenebrionids, which are the ones so easily confused with carabs until the antennæ and back legs are examined. One of the commonest of these is the *Adelium*, which is a bronzy-brown colour, with punctures or pits in the elytra, and a fine coating of soft hairs, giving the beetle a soft bronze colour.

(b) **Metallic tenebrionids.**—These are often very pretty, of a bright bronze lustre, or sometimes green and blue "shot" colours. Many of these give out an obnoxious odour when touched, and little boys call such "stink beetles." *Chalcopterus* is the commonest variety, the name chalco-pterus suggesting that the wings are coloured like "peacock copper ore."

The elytra are often very long in proportion to the head and prothorax in some of these beetles. These are often found in groups under loose bark or in depressions in tree trunks.

(c) **Piedish tenebrionids.**—These are black beetles and vary from the huge piedish beetle found out West (*Helaeus sub-serratus*), (Plate 30, Fig. 2) to the small ones found commonly under logs and stones and which have just a little rim round the edges. The Helæus has a regularly broad rim round head, thorax and elytra, and the whole is soldered to form a solid mass. It is wingless. *Pterohelaeus* is the common smaller type. They are sometimes called tortoise beetles. Most tenebrionids are found in the ground under logs, or in crevices, or under bark.

The Life History of Carabs.

(Plate 30, Figs. 1 and 3.)

These are often called the ground predaceous beetles. The eggs are laid under logs, stones, etc. The larva hatches out: it is an elongate grub with very tough integument, and three pairs of strong legs, for like the adult, this grub is predaceous and hunts for other larvæ, worms, etc., and moves very quickly. At the end of its body are two processes which aid in locomotion. It pupates in soft soil under logs, or in rotting wood of logs lying on the ground.

Carabs being predaceous on other insects often rid us of pests such as cutworms and weevil larvæ. A few species eat plant tissues such as seeds and young corn. One of the commonest carabs found under logs is the *Notonomus*, with a number of fine lines running down its wing covers. It is a small beetle about half-inch long. *Clivina* is another common rather slender carab found under logs in numbers in springtime. The handsome green metallic carab, with long, very fine running legs, is called *Calosoma*. We found the large handsome black carab *Hyperion* under a log. It was nearly three inches long—rather oblong in form with large strong mandibles. The "Bombardier Carab" shows a very curious method of protecting itself from stronger enemies. When disturbed it emits a kind of gas which is ejected from the end of its body with a miniature "pistol shot" report, and the gas becomes "smoky." This is done to startle its enemy and to enable it to gain a little time to escape.

TIGER BEETLES.

Family Cicindellidæ.

(Plate 31, Figs. 1, 2 and 3.)

This is a small family of carnivorous beetles, and worth noticing, if only for the curious formation of the larvæ.

The adult is easily distinguished from carab by the very prominent eyes, and longer and narrower prothorax. The legs are very strong, and specially fitted for running, for it chases its prey. The mouth is very strong, and suitable for seizing and holding. These beetles are found in sandy districts—along the seashores, and beside pools. They hunt chiefly at night.

The larva (Plate 31, Figs. 1 and 2) is a dirty looking grub with a very large head, and thorax bent at an angle, and on the fifth segment is a hump with two hooks on it. (Plate 31, Fig. 2a.) The larva bores a vertical tunnel sometimes a foot deep. It plugs up the hole of the tunnel with its head, and should some luckless victim walk over it, it is seized in its powerful jaws, taken down, and eaten. The hump and hook help to keep the grub in the position at the mouth of the burrow. The female lays eggs in the ground, and the larva pupates in the soil.

A common type is *Cicindela ypsilon*, found on the beaches of the coast.

Fig 1. Larva of Tiger beetle in hole.

Fig 2. Larva
a - Hump with hooks

Fig 3. Tiger Beetle.

Fig 4. Buprestid Larva.

Fig 5. Pupa.

Fig 6. Antenna.

Fig 7. Buprestid Beetle

Fig 8. Click beetle.

Fig 9. Underside of Click beetle
a. Spine b. Cavity

Fig 10. Wire Worm (Larva of Click beetle)

ROVE BEETLES.

Family Staphylinidæ.

(Plate 30, Figs. 6 and 7.)

These are easily distinguished by their short elytra, which resembles the tegmina (cover wings) of earwigs. In general appearance, too, the rove beetles somewhat resemble the earwigs, having an elongate body, and with the exception of the part covered by the elytra, the whole abdomen is exposed. (Plate 30, Fig. 6.) Hence the dorsal side of the abdomen is much hardened, whereas in most beetles the upper or dorsal side is softer than the ventral, being protected by the elytra. Most rove beetles have the habit of turning up their tails when touched, so that enemies may think they sting, and this is a probable means of protection from predaceous insects.

Rove beetles move very freely and usually fly very well, having the flying wings tucked under the cover wings. They are often found under logs, in stables and near decaying animal or vegetable matter. Some species capture and devour small living creatures. We have noticed repeatedly a slender little Rove beetle on the Woollahra Point Beach. When one is seated on the grass on the upper part of the beach, it alights on one's book or clothes and turns up its tail now and again and then

flies off. One of the largest rove beetles is the Australian "devil's coach horse," a name borrowed from the large common Staphylinid beetle in England. It has a red head, hence its specific name (*Creophilus erythrocephalus*). We have found it in dung.

Some staphylinid beetles are said to live in harmony with ants. Sharp thus describes one species: "The beetles are never found out of ants' nests, or at any rate, very far from them. The most friendly relations exist between them and the ants; they have patches of yellow hairs, and these apparently secrete some substances with a flavour agreeable to the ants, which lick the beetle from time to time. On the other hand the ants feed the beetles; this they do by regurgitating food, at the request of the beetle, on to their lower lip, from which it is then taken by the beetle. The beetles in many of their movements exactly resemble the ants, and their mode of requesting food, by stroking the ants in certain ways, is quite ant-like."

Other staphylinids are present in ants' nests, but not as friendly guests. They attack the larvæ and eggs of ants, and even an adult (if one should be alone).

The larvæ of rove beetles live on insects or remains of animals—they are elongate and may have two tail-pieces like the carabs, but have not such stout legs. Mr. Zeck has recorded rove beetles in the nests of ants in New South Wales.

Family Malacodermidæ.

(Plate 30, Figs. 8 and 9.)

This family is regarded as the most primitive of all beetles. The elytra are soft and are not co-adapted to the sides of the body; the body segments are looser and are not so closely united as is the case with most beetles. The commonest type is the "Soldier Beetle" (*Telephorus pulchellus*).

Larvæ are found under logs. Froggatt says of one of these beetles: "The larvæ are curious smoky-black creatures with blunted spines along the sides of the body, and live under stones or logs."

Fire-flies or glow-worms (Plate 30, Fig. 9) belong to this family. The female glow-worms are often wingless and larva-like, and send out a strong intermittent phosphorescence. These are seen in the gullies of the Blue Mountains in summer and are nocturnal in habit, as the "light" suggests.

Nearly all of the sub-family Lampyrides give off phosphorescent light. Sharp says: "the luminescence is most marked in the female imago, in which it is concentrated near extremity of the abdomen."

Fire-flies are usually gregarious in habit: it is said that only the males emit the light. We have fire-flies in Australia, the commonest genus being *Luciola flavicollis*. Froggatt says: "Our fire-flies are small, light brown beetles, which during the day cling to the foliage, flying about at night emitting a bright flash of phosphorescent light from the tip of the abdomen as they move their wings. Several species are found on the Blue Mountains and in the tropical scrubs of North Queensland."

CLICK BEETLES OR SKIP JACKS.

Family Elateridæ.

(Plate 31, Figs. 8, 9 and 10.)

The adult is very like a homely Buprestid beetle, but is a little more linear in form. The antennæ are more decidedly serrate, and the prothorax is not so broad, but is longer and there are two prolongations into spines, one on each side of the prothorax at the posterior end. Ventrally, there is a prothoracic spine in the middle, which fits into a corresponding cavity of the mesothorax, and this spine is capable of moving freely in and out of the cavity, and aids in jerking the body from a few inches to some feet away. It is owing to this habit of jerking itself into the air that the popular name "skip jack" beetle has arisen. The colour is usually brown and the general outline is smooth.

The larva is the "wire worm" (Plate 31, Fig. 10). It is long, narrow, and cylindrical, with three pairs of strong, horny legs, and capable of quick movement in the soil. The integument is hard and polished looking, yellow to brown in colour. It is said to live up to two or three years. It feeds on roots of plants and on decaying vegetation. Some are said to be carnivorous, others to emit phosphorescence.

One night when sitting quiet we observed a click beetle on the floor; we touched it and it at once became quite still as if dead. In a few seconds it moved again: we touched it, with a similar result, but it remained quiet for a longer period. We continued to touch it at intervals, several times, and each time the quiet period became much longer, until finally it remained quiet for an hour, pretending to be dead or at least to be taking the best means of attracting as little attention as possible.

Family Buprestidæ.

Buprestids, Jewel or Flower Beetles.

(Plate 31, Figs. 4, 5, 6, 7.)

The adult beetles feed on the nectar and pollen of flowers. Scores may be found on the flowers of the Dwarf Apple (*Angophora*) in the hot summer months of December and January. The smaller jewel beetles may be found on almost every nectar bearing open kind of flower such as *Leptospermum*, or Tea Tree, *Eucalyptus*, *Kunzea*, etc.

The adult is a smooth beetle often of most gay colours, or with beautiful metallic tints; there are also a few more homely coloured ones. The appendages of the body are tucked away out of sight in repose, and this intensifies the smooth appearance. The elytra are very strong. These beetles are broad at the head and thorax and taper often to a relatively fine point at the tail. The large prothorax fits tightly against the mesothorax and

on the under side there is a spine on the prothorax which fits into a groove of the mesothorax. As this fits tightly into the groove there is no free jerking movement such as characterises the click beetles, the last family with which we dealt, but still the prothorax can be freely moved in most species.

The larva (Plate 31, Fig. 4) is a wood-borer, and some of these are very large and long. One specimen we collected was three inches long. The head is usually very small but with strong gnawing jaws and the thoracic segments are very large, while the segments of the abdomen taper towards the end; hence the larva is often "a hammer-headed" grub. We have found the elongate naked pupa in the burrows which the larvæ made in wood. The burrows are elliptical in section. These grubs, especially the genus *Stigmodera*, attack the Eucalyptus trees. The clearly marked black and yellow *Cyria* attacks the trunks of the christmas bush (*Ceratopetalum gummiferum*), and the native honeysuckle (*Banksia*). Another genus, *Cisseis*, attacks wattle trees while yet another (*Ethon*) forms galls.

LEAF-EATING BEETLES.

Family Chrysomelidæ.

(Plate 32, II.)

Usually small elongate beetles with filiform (thread-like) antennæ and often with beautiful metallic tints, or brown colour with black markings. The foot (Plate 32, Fig. 11) of these beetles is curious. The third joint is deeply lobed and the tiny fourth joint is lodged between these lobes of the third joint, so that one might easily think that the feet had only four joints instead of five. The larva is usually a leaf eater.

Type *Paropsis.* (Plate 32, Fig. 7.) This beetle differs from most chrysomelids in being rounded and vertically thick; the head, prothorax, and abdomen fit together very closely. Except that it is usually larger and is not so brilliantly marked, it resembles in general shape the ladybird beetles. There is a great variety in the markings and general colour of *Paropsis*, and some of them are very pretty, the general colour being buff to dark brown, with or without markings. As the *Paropsis* walks the deeply lobed third joint which rests on the leaf reminds one of a pair of slippers on the feet of the beetle, giving it rather a comical aspect. The tarsi are flat on the under side. The eggs are deposited in a very curious manner. They are ar-

Fig 1 Larva.

Fig 3. Eye.

Fig 2. Pupa.

Fig 4. Adult.

Life History of Longicorn Beetles.

Fig 5. Egg clusters of Paropsis.

Fig 6. Larva of Paropsis

Fig 7. Paropsis Adult.

Fig 8. Leaf with Paropsis Larvae.

Fig 9. Pumpkin Beetle

Fig 10 Metallic Chrysomelid

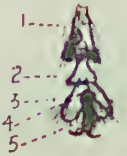


Fig 11. Foot of Paropsis 5. Joints.

ranged in clusters (Plate 32, Fig. 5) round a thin stem of the young branches of gum trees. The clusters are seen to be arranged in regular longitudinal rows, and when examined with a lens are beautiful. The shell is fawn coloured, and the egg is oblong with four horn-like protections at the apex. Two horns are long. and two are short. Running down longitudinally are four strips or thicker bands of a reddish brown colour. The eggs adhere to the twig, and to each other only at the base; they are free in the upper part. However, they can be loosened from the twig in a mass and drawn off, leaving a little hole running right through the centre of the egg cluster or rosette, for it just looks like a rosette viewed transversely. There are 20 to 70 eggs in a cluster.

The larvæ (Plate 32, Fig. 8) are hatched and are found in clusters in the daytime, and can thus be mistaken for the sawfly grubs. They pupate in the soil.

Another well-known chrysomelid is the Pumpkin beetle. (*Aulacophora olivieri.*) (Plate 32, Fig. 9.) It is a small elongate beetle with orange coloured elytra marked with four black patches. It is often mistaken for a ladybird beetle on account of its colour, and also because one of the ladybirds is also a pest on the pumpkin. But the shape of the pumpkin beetle is not round like the ladybird. These beetles devour the fleshy part of the leaves of the pumpkin, leaving only a skeleton formed by the veins, and are very fond of collecting in the large yellow pumpkin flowers.

The larvæ are elongate white grubs which have

been found tunnelling and feeding in the stems of pumpkin vines, but the natural food of this indigenous beetle-pest has yet to be discovered. The larvæ pupate in the soil.

Mixed lime and tobacco dust shaken on to these plants is said to be one of the best means of reducing this pest. There are numerous metallic or prettily marked Chrysomelids (Plate 32, Fig. 10).

PLANT-EATING BEETLES.

Longicorns.

Family Cerambycidae.

(Plate 32, I.)

The adult (Plate 32, Fig. 3) is a decidedly elongate oblong beetle, more or less flat, and usually with very elongate trailing antennæ often longer than the body.

Some longicorns are rather thick-set, and these may have shorter antennæ which are held hoisted over the back like true horns, and, although they are shorter than those of some longicorns, they are longer than the antennæ of most beetles. The antennæ taper towards the tip and the joints are usually long and well defined. The eyes are notched and partly embrace the antennæ (Plate 32, Fig. 4). The foot is similar to that of the chrysomelids.

The elytra are frequently covered with short hairs and patterns are thus formed, producing in many cases beautiful examples of protective colouration which blends with the bark, etc., on which the insects are found. One of the best examples of such protective colouration was shown by a longicorn which we found on the *Casuarina* or she oak. The body of the beetle was of a soft green colour and was elongate, and was placed along a larger

stem. The antennæ were a little over twice the length of the body and were most wonderfully like the young branchlets of the sheoak. We only noticed that a beetle was present when it moved.

Longicorns are sometimes found under bark, and these are usually very slender and rather flat beetles. The *Phoracantha* or "firewood beetle" can be seen in billet wood, wattle and eucalyptus chiefly. There is a very odd-looking longicorn called *Hesthesis*, which has colouring similar to a bright coloured wasp, for it is brown and bright yellow. Its elytra are very short and its flying wings are thus exposed, making the likness to a wasp still greater. This is supposed to be a case of protective mimicry.

One of the largest longicorns and one which is fairly broad is the *Macrotoma*, a large buff or brown coloured beetle with rather soft elytra and with long jointed antennæ, the joints being quite large and clear. This may be mistaken by beginners for a cockroach until the wings and antennæ are examined.

The larva (Plate 32, Fig. 1) of longicorns is a wood borer and a pest. It has a small head with stout gnawing jaws and enlarged thoracic segments, but this hammer-like character is not so pronounced as in the case of buprestid grubs. It pupates in the wood, making a pupal chamber by plugging up part of the burrow near the surface of the branch with sawdust, which it has made in boring. The pupa is elongate. (Plate 32, Fig. 2.)

WATER BEETLES.

(Plate 33.)

We will consider three families—

I. **Gyrinidæ** or "whirligigs."

II. **Dytiscidæ** or "water tigers" or "diver beetles."

III. **Hydrophilidæ** or "lazy water beetles."

I. **Family Gyrinidæ.** This beetle (Plate 33, Figs. 2 and 3) can be distinguished by the following characteristics: (a) The habit of whirling on the surface of the water; (b) It has two pairs of eyes, an upper pair to watch for enemies in the air, and an under pair to watch for enemies in the water below. Thus they are sometimes called "daddy four-eyes"; (c) The front legs are longer than middle and back pairs and look like a pair of oars; the two pairs of back legs are broad, short and paddle-like, alternately expanding and then collapsing (Plate 33, Fig. 4); (d) The tip of the abdomen is exposed; (e) antennæ very short.

Habits. Gyrinids or whirligigs can dive to get away from an enemy. They can also fly away to other ponds. It is rather a surprise to find that water beetles can fly in the air, but the elytra fit very tightly round the body, and the spiracles are under them. The wings are thus kept beautifully dry. When they dive they have to take

down a supply of air, which can be seen at the end of the body as a beautiful glistening silver ball; they do not stay long under water. These beetles are carnivorous, and feed on any water creatures they can capture. They also seize any flying insect which may fall into the water.

The larva (Plate 33, Fig. 2) lives in the water and does not need to come to the surface to get an air supply. It has plate-like projections or gills at the sides of the body which help it to move about in the water, and also aid in the breathing of the larva. The metathorax carries the two main breathing spiracles. The eggs are small and cylindrical, placed in parallel rows on leaves of aquatic plants. The larva pupates on water plants.

II. Family Dytiscidæ or Diver Beetles (Plate 33, Fig. 1, a, b, c, and d).

(a) The antennæ are filiform or thread-like; (b) There is only one pair of eyes; (c) The back legs are long and like a pair of oars; they are widely separated from the middle pair because of the large coxæ or thighs of the hind legs which cover the greater part of the thorax. They are the main organs of locomotion and are clothed with collapsible hairs on the lower part of the leg; the hairs alternately spread out and then collapse; (d) The tip of the abdomen is not exposed. A common genus is *Cybister*. (Plate 33, Fig. 1, d.)

Habits. These beetles are predaceous, and very fierce; they will attack other water creatures The elytra are smooth and curved tightly round the body, except at the tip of the abdomen. The elytra thus cover well the flying wings and spiracles,

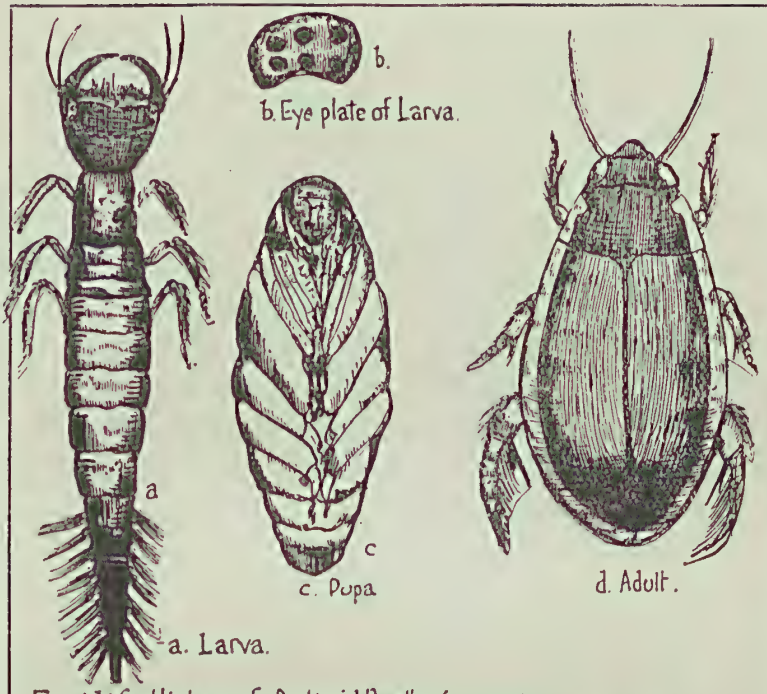


Fig1. Life History of Dytiscid Beetle (*Cybister*)

Fig2. Larva of Whirligig Beetle

Fig3 Whirligig Beetle.

Fig4. Swimming paddle of same.

Fig5. Hydrophilid Beetle.

Fig6. Egg raft of Hydrophilid

It is interesting to note that all water beetles have a general smooth appearance, narrowing at the sides to enable them to cut through the water. Some have longitudinal grooves, but the general surface of such beetles is smooth.

These beetles have to take down a supply of air. To do this a beetle rises to the surface of the water and protrudes the tip of the abdomen. It raises the elytra and draws in a supply of air into a cavity between the elytra and the back of the beetle.

These beetles can fly long distances from pool to pool. The eggs are laid on water plants. The female cuts a slit and inserts an egg in each slit. The larva (Plate 33, Fig. 1) hatches out and feeds on small insects and young tadpoles. It is very voracious, and is called a "water-tiger." It has large mandibles, which are hollow, and are capable of seizing and piercing the victim and then sucking the juices of the body. The mouth proper is small. At the end of its body are fringes of hair (Plate 33, Fig. 1, a), and these aid it in its movements in the water and also help it to float to the surface when it needs an air supply. The air is taken in by the two enlarged terminal spiracles only.

The dytiscid larva has curious eye-plates on which we found six single eyes arranged in three pairs (Plate 33, Fig. 1, b).

Family Hydrophilidæ (Plate 33, Figs. 5 and 6) lazy water beetles. These are so called because they are neither so active nor so fierce as the dytiscids or gyrinids. They are mostly vegetable feeders, are really water scavengers feeding on decaying

vegetation as well as on living plants; a few are carnivorous, and these are more active. They breathe by taking an air supply down into the water, this is spread out like a beautiful silver film over the under surface of the body. It gets the supply of air by raising the antennæ out of the water and then drawing them down, thus an air bubble is captured and sent over the lower surface of the body.

These beetles are somewhat similar to dytiscids, but can be distinguished by the structure of the antennæ. They are short, but with the lens can be seen to consist of three parts: (1) the base, of one or more elongate joints; (2) the middle part, of a number of small joints; (3) a terminal part, where the joints are broader, forming a small club. The legs are similar to those of the dytiscids or divers. The back legs are longer and oar-like, the front pair short and paddle-like.

Habits. The mother insect of many species forms egg cocoons containing many eggs, which may be fastened to water plants, or carried for some time by the mother. These beetles, like other types, have flying wings and move from one pond to another. They are often captured when flying around lights at night. The larvæ are predaceous even when the adult feeds on plants.

FAMILY CURCULIONIDÆ.

(Weevils.)

(Plate 34, II.)

I.

The head is prolonged into a rostrum or snout. This varies in length and thickness, and so weevils can be very generally divided into two groups:—

A. Long snouted weevils (Plate 34, Fig. 7).
B. Short snouted weevils (Plate 34, Fig. 8).

The apex of the beak is more or less expanded to allow of the inclusion of a pair of strong jaws by means of which the insect bores into wood, grain, etc. The female is said to use the rostrum to bore a hole; it then places an egg in it and uses the rostrum to push the egg further back into the hole. The antennæ (Plate 34, Fig. 9) are fixed on to the rostrum, sometimes near the base, sometimes nearly in the centre. An antenna consists of a large base joint much elongated, called the **scape,** and an upper many-jointed part which is placed at an angle to the scape; thus it is elbowed. The integument is very hard, and the elytra curve over the sides and fit on to the body like armour plate. Many of the weevils have knobs and projections which make them look like the rough bark on which these species are found:

this is a protection. Many weevils pretend to be dead when touched.

The larvæ are mostly borers; some of them bore into wood, and others into grains, etc. The grub is a maggot-like creature, but is fatter than a typical maggot. It is devoid of legs. It pupates in the medium in which it bores.

Wood-boring weevils are serious pests; they often bore round a branch in a circular track and "girdle" it till it snaps off with the wind. This is often seen in *Pittosporum* trees. There is the apple root borer, which is one of our more serious orchard pests.

The life history of a weevil can easily be studied if one puts some exposed maize in a box or tin and keeps it for some time. It is usually infested with weevils (Plate 34, Fig. 12), and larvæ and pupæ may be seen. These tiny black weevils are very characteristic of this group.

The Botany Bay Diamond Weevil (*Chrysolophus*) is a great favourite with children who collect, and they are vastly amused at its pretence to be dead when touched. It feeds on leaves of wattles and other bush plants. Its larva is a wood borer.

Fig 1 Larva of *Leis conformis*

Fig 2. Pupa.

Fig 3. Adult

Fig 4 Eggs of *Leis conformis*

Fig 5 Larva of Pumpkin Lady bird

Fig 6 Foot of Ladybird

I Lady Bird Beetles (Coccinellidae)

Fig 7 Long-snouted Weevil
a Proboscis

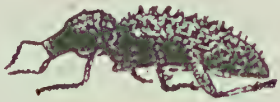


Fig 8 Short-snouted Weevil

Fig 9. Antenna.
a Scape.

Fig 10 Leaf-weevil

Fig 11 Larva of Weevil

Fig 12. Weevil in grain of corn

II Weevils (Curculionidae)

LADYBIRD BEETLES.

Family Coccinellidæ.

(Plate 34, I.)

These beetles are very characteristic in form—they are more or less rounded, the head, thorax, and abdomen fitting very closely; the head is concealed by the thorax. The feet have only four joints and appear to have but three: the third joint, however, is so very small as to escape being readily seen even with a lens. These beetles are very conspicuous, usually with bright colours; they are protected from enemies—such as birds—by having a distasteful fluid in the body which thus saves them from attack. They are great favourites with children, who sing to them the well-known rhyme "Ladybird, Ladybird, fly away home." Ladybirds are free from enemies to a remarkable extent; they multiply very rapidly, and in most cases are friends to the agriculturist and gardener, for they are carnivorous, feeding on aphides, scales, etc. The eggs are placed vertically in groups (Plate 34, Fig. 4). The larvæ (Plate 34, Fig. 1) are very active grubs and seem to be always hungry; they seize aphides and soon suck them dry, leaving only the skins. The larva of the common garden ladybird (*Leis conformis*) is dark-coloured (due to hairs or projections), with two orange-coloured transverse bars in the upper part of the body. The larva of the ladybird

pest *Epilachna* **28-***punctata*, or the 28-spotted lady bird, is of a general creamy colour, with bristle-like hairs tipped with black (Plate 34, Fig. 5). When very still it looks like a "plant burr." Both larva and adult feed on plant tissues and attack plants of the pumpkin family. It is a large ladybird, with 28 spots, and this genus *Epilachna* includes the only "bad" ladybirds we have with us. Another species is *E. guttata pustulata* (potato ladybird).

The pupa of ladybirds differs somewhat from the typical beetle pupa, for the mature larva fastens itself by means of a sticky secretion by the tail to a stem or to the fence. Then its last larval skin is shed and pushed to the base, and the pupal shell is seen. It resembles the pupa of a butterfly rather than that of a beetle. (Plate 34, Fig. 2.)

We have made some very interesting observations in rearing ladybirds from the egg, and will just quote a few.

Observation I.—We noted some aphides on the leaves of a garden shrub called *Duranta*, and at once kept our eyes open for the appearance of ladybirds. Later they appeared. The species was *Leis conformis*. We got two of these beetles and placed them in a box. Next morning there were a number of eggs. We then put the beetles back on the tree. The eggs were laid on the 5th of February and hatched on the 6th. The small larvæ were quite dark. We placed each one in a separate box, and the following is what we observed of No. 1 larva: We placed some sprigs of *Duranta* with numerous aphides present into a box with the larva. We put

an aphis on to a needle and placed it under the head of the larva, but it turned aside and would have none of it. It passed by the nearest aphides and just chose its own particular victim. We saw it catch the aphis with its front legs and then began sucking it. This went on till several aphides of varying sizes were devoured. Then it rested awhile. On the 10th of February the ladybird larva was very quiet and would not touch any aphides. Next morning it was in the same position, but had turned a dull brown colour, and there was a distinct white line in the centre of the back from the head to the thorax. After watching it for half an hour it began to move its legs, one at a time. To look at it one would think it was exercising its limbs; but upon close observation through the lens we could see that it was preparing to change its skin. In a few minutes this white line before mentioned gradually opened, beginning at the head and continuing down the thorax. Then the larva swayed from side to side, gradually raising itself till it was free from the old skin. It was at first greyish-looking, but in a few hours became black, and on the 7th segment had a yellow band. After a little time it was as active as ever, looking round for something to devour. In the meantime, so effectively was the work of killing the aphides done by the ladybirds on the plant that in a few days there were none left to supply our captives. Previously we had experimented with these larvæ and reared them on the juice of oranges, on which they flourished. We tried the juices of peach and pear, which were then in season, and this larva seemed in no way put out

but thrived on this new food. On the 14th of February it changed its second skin. We noticed that the larva at this stage was not so dark, and that there were yellow markings on the 4th and 7th segments, and also along the sides of the body. After feeding for two days it attached itself by the tail to the side of the box, and pupated on the 16th of February. The adult emerged on the 21st of February by breaking open the pupal skin. It was quite yellow with no black marks at first, but in a very short time the black spots appeared, and in about half an hour altogether it was a normal *Leis conformis*.

Observation II.—We placed another ladybird in a box, a yellow ladybird, of the species *Coccinella repanda*, with black markings but not regular spots. The eggs were laid on the 10th of February; the tiny larvæ hatched on the 12th of February. They were yellow at first, becoming quite black in a little time. They changed the first skin on 17th and 18th of February. There were more yellow patches on these grubs than on those of *Leis conformis*. There was a broad yellow transverse band on the second segment: on the third, two short transverse bars, and running down from between these a longitudinal yellow band: the anal segment was also yellow as also the outer edge of the body. They changed the second skin on the 23rd and 24th of February, and pupated on the 27th, 28th and 29th of February respectively. They emerged on the 5th and 6th of March.

The larvæ of ladybirds are very voracious, and if left in a box with no food will just devour each other, beginning with the little ones. We left some

ladybirds in a box for a day and night with numerous aphides. There were seven of them, and on the next morning at 11.15 there were no aphides and only one larva left, and the latter was just finishing his meal of one of his brothers. These were larvæ of *Leis conformis*. It is not to be wondered at that the larvæ of ladybirds take to fruit juices as food, for the aphides are just full of the plant-juice which they so rapidly abstract. Of course it undergoes some change in the body of the aphis, but at any rate they can change their diet of aphides to fruit juices and back again to aphides, seemingly without any concern.

In Novermber and December we observed larvæ of *Leis conformis* on a vine of *Wistaria*. There were no aphides on the leaves, but we noticed that most of the leaves were turning first a mottled green, then yellow, and then they fell. We examined some of them with a lens and saw that the whole plant was badly infested with a mite, and that the ladybird larvæ were devouring them. The mites could be seen with the naked eye as tiny fawn or dark-coloured dots and were very active, moving quickly over the leaf.

We observed also that many of the ladybird larvæ were devouring their fellows as the latter were changing their skins.

Probably the chance of a larger repast was tempting, for the mites were tiny, and kept the ladybird larvæ busy devouring them.

ORDER LEPIDOPTERA.

(Butterflies and Moths.)

(Plates 35, 36, 37, 38 and 39.)

Characteristics. 1. Insects with two pairs of wings covered with modified hairs in the form of flat scales (Plate 36, Fig. 4). These are very beautiful when seen under the microscope and resemble petals of flowers.

2. The mouth parts (Plate 38, Figs, 5, 6 and 7) are modified to form a sucking tube more or less long. This can be coiled up like a watch-spring and fitted into a socket in front and on the under surface of the head. It is in the form of two half-tubes which fit together. Each half-tube has a strong supporting area; also a groove on the inner side (Plate 38, Fig. 7). The grooves fit to form a long tube.

3. The metamorphosis is complete or perfect.

Butterflies and moths differ in certain details and can be classified on these differences into two groups:—

1. **Rhopalocera** (Butterflies). 2. **Heterocera** (Moths). These two groups are not distinct, there being intermediate types which have some of the characters of each group.

Butterflies have the antennæ more or less thickened at or before their terminations (Plate 35, Fig. 3). A more or less narrow waist or constriction exists between the thorax and abdomen. Then,

butterflies usually fly in the day time, are brightly coloured, but have a zigzag flight by means of which they dodge their enemies. Some few species only fly at dusk. The wings in repose are usually erect, and the underside is very often marked in such a way as to blend with the surroundings—this is a protection. Some butterflies, when in repose, resemble leaves.

Moths. The antennæ of moths vary in form (Plate 36, Figs. 5, a, b and c); they are not clubbed except in a few instances. The constriction between the thorax and abdomen is less, or is hidden by thick hairs or "fur."

Moths fly most frequently at night: such forms as fly in the day are termed "day-moths;" *e.g.* grape vine moths. The wings are held horizontally in repose, and on the whole sombre colours prevail which often blend with the surroundings. The mottling and marking of many of the moths make the wings of some of them most exquisite studies in soft colours.

Taking a general view of the **life history** of the Lepidoptera, we find that the eggs are deposited on or near the food supply of the larva, which is mainly vegetable. From the egg comes the larva (Plate 35, Fig. 1), which is a **caterpillar,** which may be smooth, hairy, or ornamented with spines (Plate 38, Fig. 2). The larva has usually three pairs of horny legs, four pairs of fleshy legs, and two anal claspers. It eats voraciously, and moults or sheds its skin several times. Having reached the condition of the full-grown larva, it changes into the pupa or resting stage, in which it eats no more and

ceases to move about, for it is in this stage that the final stages of development into the perfect insect take place. This pupa (Plate 35, Figs. 4, 5, 6, 7 and 8) may be quite free from any surrounding covering, or it may be enclosed in a cocoon or sheath of woven silk (Plate 39, Fig. 4). The first type is general among the butterflies, whilst the cocoon is almost invariably found in the moths, for, where the larva pupates in the earth the soil takes the place of the cocoon when no distinct cocoon is made. In course of time the perfect insect emerges from the pupal shell. At first it is wet and limp, with crumpled wings and lengthened abdomen, looking a very sorry picture of what we perhaps expected.

Mother Nature soon completes her work; the abdomen contracts, the rather miserable-looking creature begins to exercise its legs, and gradually the air is sent through the crinkled, deformed-looking wings, and they slowly expand; then it exercises wings and legs and tongue, and eventually, after little resting spaces, it flies off a very beautiful object.

Both butterflies and moths are divided into numerous families according as they possess certain features in common. We shall consider some of the more familiar families, and then study a few types belonging to such families as are particularly interesting, or are of economic importance.

Fig 1 Larva of Wanderer Butterfly

Fig 2 Larva preparing to pupate.

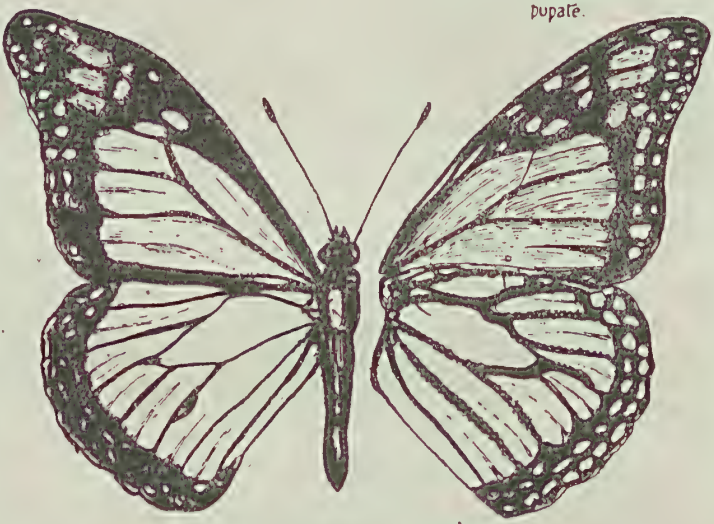


Fig 3 Adult Wanderer (*Danaida*)

Fig 4. Pupa of Danaida

Fig 5. Pierid pupa

Fig 6. Hesperid Pupa

Fig 7 Papilionid pupa a girdle

Fig 8. Lycaenid pupa.

FAMILY NYMPHALIDÆ.

(Brush-footed Butterflies.)

This family is divided into three sub-families:—(a) Danainæ, (b) Nymphalinæ, (c) Satyrinæ.

Family Nymphalidæ.

Characters—(1) Larva smooth, or at times hairy.
(2) Pupa usually suspended by the tail.
(3) Perfect insects, medium or large size; front legs imperfectly developed, so that they are of no use in walking.

Sub-family Danainæ.

Characters—(1) Larva smooth, but with fleshy threadlike appendages.
(2) Pupa suspended by the tail, metallic markings often present.

Waterhouse and Lyell, in "Butterflies of Australia," thus record of Danainæ:—"The **Food Plant** *Asclepias*, *Aristolochia*, and other allied plants that exude a milk-like juice when broken. . . . **The habit** of the larvæ of this sub-family of feeding upon various species of *Aristolochia* ("dutchman's pipe") and allies seems to have resulted in the transference to the butterflies of some of the distasteful properties of the food plant. Close observation and experiment have shown the butterflies to be almost immune from the attacks of birds, to whom they are evidently most distasteful. Including even the

migratory *Danaida archippus*, the butterflies are without exception of slow and laboured flight: the colours are distinct and striking, yet the insect upon the wing seems quite unconscious of danger.. The genus *Danaida* is of special interest on account of the immunity from the attack of birds, and from the close resemblance to it of butterflies of non-immune families."

Life history of *Danaida archippus* (Plate 35, Fig. 3), (*Danaus menippe* of other authors): The "Wanderer"—This butterfly can be seen in early spring, and till late autumn. It is a fairly large butterfly, with wings of bright orange-brown, the veins outlined in black. The male is distinguished by a small thickened patch of black scales near the centre of the hind wing.

The eggs are laid singly on or near the leaves of the "wild cotton" bush (*Gomphocarpus fruticosis*), which is the food plant of the larva. They hatch in a few days; the caterpillar (Plate 35, Fig. 1), is at first black and thread-like, but when older is banded in black and yellow. At each end of the body on the upper surface is a pair of flexible black appendages.

On pupating, the larva attaches itself by the end of the body by means of a silky secretion, and hangs head downwards (Plate 35, Fig. 2). It then curves over and the body shortens, and by a series of convulsive jerks the old skin is pushed upwards in a very clever manner.

The pupa is suspended by the hooks at the end of the body, which are caught in the silken pad spun by the larva. At first the pupa is a pale

green colour, with ornamentations of gold; it is very pretty. Later the colour darkens and finally, when the adult is about to emerge, one can see the markings of the insect, for the pupal shell is transparent. In warm weather, from 9 to 15 days are passed in the pupal stage. Pupæ found on the food plant are usually parasitised, hence are very often found on bracken or other plants near. *Danaida* is an introduced butterfly.

Danaida petilia is a much smaller "wanderer." If the larvæ of these butterflies are placed in a cardboard box with a glass lid, and the box then placed on its side, one can watch the life history with ease.

We brought home some pods of the wild cotton from Port Hacking to Sydney, and from the seeds a couple of plants grew. For the first time we noticed the visits of a beautiful *Danaida*, which came several days in succession and laid eggs on the plant.

Another interesting genus is *Euploea*, with wings of velvety black with cream patches. The children often admire and bring in their beautiful golden or silvern pupæ.

SUB-FAMILY NYMPHALINÆ.

Characters: 1. Uusually medium-sized butterflies.

2. Larvæ frequently clothed with spines or tubercles; a few are smooth.

3. Pupæ suspended by the tail, and with a few exceptions are elongate and angular.

The butterflies are usually of strong swift flight and delight in hot sunshine. Many of them have peculiar tastes, being attracted by exuding sap, decomposing fruit, carrion, etc.

Type: The Meadow Argus, *Precis villida* (*Junonia villida* of some authors). It is a brown and orange-coloured butterfly with eye-spots on each wing, and with three characteristic transverse orange markings on the front of the fore-wings. The under surface of the wings is a mottled grey. It is very quick and is often hard to catch.

The **larva** is dark brown, clothed with tiny branched spines.

Food plants: snapdragon, plantain, Australian centaury.

Pupa is mottled brownish-yellow, suspended by the tail near the food plant; it is not smooth.

The Australian admiral (*Pyrameis itea*): This is a brown butterfly, distinguished by the dark brown to black at the apex and outer edges of the wings; the inner part of the wings is golden brown.

There are four small eye-spots on each of the hind wings.

The food plant is the nettle. The larvæ are gregarious, and have formed the curious habit of spinning a silken thread, and drawing the nettle leaves together between which they find shelter. They are black to grey in colour.

Pupa is purplish-grey with angular projections. They are sometimes found quite golden, but in this case are parasitised.

Another is the "tailed emperor," *Eulepis sempronius* (*Charaxes sempronius* of some authors). The general colour of the upper surface is bluish-cream, with black towards the margins; the hind wings are "tailed." The under-surface is quite unlike the upper, being banded with shades of brown, brick-red, and creamy-white. The eggs are laid singly on leaves of the food plant.

The **larva** is bluish-green, with a crescent-shaped band on the seventh and ninth segment of orange colour. The head is surmounted by a series of horns (from 4 to 6).

Food plants: *Acacia baileyana*, *A. longifolia* and two other species: *Robinia pseudo acaciae*, and the camphor laurel.

Pupa: Delicate sea-green colour, and smooth; it turns to bronze colour when the adult is about to emerge.

Waterhouse and Lyell record: "We have taken this butterfly feeding on the juices exuded by shrubs; the late Mr. G. Masters once found several examples round the leaking bung-hole of a wine

barrel. When in this semi-intoxicated condition it is easily captured; at other times it is of exceptionally strong and rapid flight." It also feeds on moist decaying vegetable matter.

Hypolimnas bolina is perhaps one of our most beautiful butterflies: it is confined to northern New South Wales. The male and female differ widely in colouring. The male is a rich purplish-black, with a central patch of pale heliotrope in each wing: there are markings of heliotrope and white. The female has ground colour of rich brownish-black with patches of orange-brown and white. But the colouring of the female is very variable, especially in the north.

The larva is dark, with clusters of branched spines.

Food plant: *Sida retusa* (paddy's lucerne).

The pupa is suspended by the tail and ornamented with short tubercles.

SUB-FAMILY SATYRINÆ.

Characters: 1. Small or medium-sized butterflies, having the under-surface of the wings ornamented with eye-spots. Similar spots may occur on the upper surface.

2. The green-brown larva, smooth or sparsely covered with hairs. It tapers towards head and tail, and the latter is forked. Food chiefly grasses: feeds at night.

3. Pupa short, not angular; suspended by the tail, except in two or three species, which pupate on the ground. Note that whereas in other species if the attachment is taken away, so that the insect has nothing to push against when emerging, the result is a cripple; with such natural types though it has nothing to press against, it does not emerge as a cripple.

Waterhouse and Lyell record: "The *Satyrinae* are essentially shade-loving species, usually found in wooded gullies and in the shadow of cliffs or trees. They are often to be seen resting in company in cavities of a cliff face, or beneath overhanging rocks. At dusk they are sometimes so sluggish that they may be lifted from their resting place with the fingers or forceps. Their flight is weak, the one exception being *Melanitis*, which has a swift, elusive flight when disturbed in the daytime. All the species

are local in their habits; they are very constant in their times of emergence, and the greater number of the males usually appear on the wing a week or ten days in advance of the female. They are usually some shade of brown with paler markings."

Type: The common brown (*Heteronympha merope*) appears in the spring, and remains till the end of autumn. The sexes differ in size, colour and markings. The male is smaller: its wings are golden-brown, mottled with black, and each wing has an eye-spot. The wings of the female have similar eye-spots, but the inner parts of the front wings are orange-brown, and the outer parts black banded with lemon-yellow.

The **eggs** are deposited in stems of soft grasses near the ground. The larva when full grown is brown in colour; the body tapers towards each end and the tail is forked. Occasionally the larvæ are green in colour.

The **pupa** does not suspend itself by its tail as is usual in this family, but lies on the ground.

This butterfly is confined to Australia; it is usually numerous in the southern parts of New South Wales, particularly along the coast and highlands. It flies low, and is thus easy to capture. It is dusky-brown in colour, each wing has eye-spots, and the front wings are crossed by a wide orange band.

The eggs are laid on the stiff blades of the sword grass (*Cladium*), and on this the larvæ feed when hatched. The **larva** is green, about 1½ inches in

length, and tapers towards the forked tail. The **pupa** is also a pale green colour, with yellow edgings to the wing case. It hangs suspended by its tail from the food plant. Care needs to be taken in hunting these caterpillars in the sword-grass, for it will cut like a knife. "Larvæ of 'browns' are very easy to rear in captivity with a little experience, and as their interesting transformations can thus be watched, the student is advised to proceed in the following manner:—Any soft grass should be planted in a pot, and provided with two bent wires crossing over the pot at right angles and the four ends inserted in the earth of the pot; this acts as a frame for a mosquito net covering. The end of the mosquito net covering should be held tight to the pot by string. Young larvæ, found by searching grasses in the gullies or such places that these butterflies frequent, can be then placed on the grass and kept under observation, or captured females may be brought home alive and placed in these cages so that they may lay their eggs on the grass. During winter time the ordinary winter grass is very suitable to use, but any soft grass will answer the purpose, for Satyrid larvæ are not confined to any particular grass."—(Waterhouse.)

FAMILY LYCÆNIDÆ.

("Blues" and "Coppers.")

This family includes some of our smallest butterflies, so often seen in grass lands. The prevailing colours are blue and copper.

Characters.—(1) Larvæ short, thick, and slug-like; caterpillars smooth, or covered with short hairs; usually feed at night, frequently gregarious. Waterhouse and Lyell record: "The larva is almost invariably flattened and slug-like, with the head retractile and concealed while at rest. Posterior segments usually with dorsal glands, which secrete a liquid much prized by ants; the ants consequently attend the larvæ, and in some cases shepherd them. The larvæ feed singly or gregariously and usually by night, sheltering during the daylight in ants' nests, under bark or stones, in curled leaves or flower buds, or in crevices of the trunk of the food plant."

Type: "The imperial blue" (*Jalmenus evagoras*). This is a small, dainty butterfly, 1½ inches across the wings. The upper surface is dusky brown, with a large central area of silver blue. On the hind pair is a bright orange patch above the tails. They are low but rapid fliers.

The larvæ are almost black, or of a dull green, marked with yellow, with a row of tubercles along the upper surface. Ants are found running over and

apparently stroking and caressing the larvæ in order to obtain the sweet fluid which they secrete. The caterpillars are gregarious. Food plant: black wattle (*Acacia decurrens*).

Pupa is a shining dark brown or black structure attached by tail and suspended by a girdle. They are in clusters, and sometimes so close as to be overlapping. Ants are in attendance, as in the case of the larvæ.

FAMILY PIERIDÆ.

(Whites and Yellows.)

The popular names have been given to this family on account of the predominance of white and yellow colours. These butterflies have a wide range. Waterhouse and Lyell records: "It is within this family that the migratory habit is most noticeable, both in Australia and elsewhere. We have observed several immense flights of *Anaphaeis java teutonia* and *Catopsila pythias* in the neighbourhood of Sydney, and their direction has invariably been from north to south; on the other hand, flights of *teutonia* we have noted in Gisborne have all been travelling almost due north. During these flights all the butterflies seemed to be steadily pursuing the one course, only occasionally visiting a flower and rarely resting until evening, excepting possibly for a time while a heavy cloud obscured the sun. In the evening and through the night these migratory butterflies often rest in company: scores of *teutonia* have many times been noticed settled on one small bough. They always choose for a resting place those plants or trees which blend most closely with their own colours."

Types.—"The caper white": *Anaphaeis java teutonia* (*Belenois java* of some authors): One of the commonest whites. It is not more than 2 inches across the wings. The upper surface is white, wit'

black margins; the under surface of front pair is similar to the upper surface, but on the under side of hind wings yellow markings are found. The larva, when full grown, is brown, with yellow tubercles scattered over it; when half grown the head seems abnormally large.

Food: Caper tree.

The **pupa** (Plate 35, Fig. 5) is more or less erect, with a girdle supporting it. The upper part terminates in a distinct point; a few angular projections are on the abdominal region. In the Newcastle district we saw a migratory flight which was not in a mass but one after another every few seconds. Their flight was down a valley, and the butterflies kept the same side of groups of trees which were present, never flying more than a few yards out of the course of their predecessors.

Another species is *Delias nigrina*. This is not a migratory butterfly. The general colour of the upper surface is a bluish-white; the front pair of wings has a dusky black patch with three white blotches near the apex. The under surface is entirely different from the upper: dusky black forms the ground mass, with a bright yellow band across the front wings and markings of bright red.

Larvæ are dark green and are gregarious; they feed on the mistletoe (*Loranthus*).

The **pupæ** are erect, with a supporting girdle; there is a pair of horns on the apex, and curved spines are scattered over the surface.

The "wood white" (*Delias aganippe*) is slightly larger than *Delias nigrina*, and resembles it. Note: the dusky black on the front wings has 8 patches

of white; the second patch is long and narrow. The under wing is ornamented with yellow and red. It flies high.

The **larva** is dull brown, and is covered with cream tubercles surmounted by white hairs. The caterpillars are found in great numbers on food plants such as native cherry and mistletoe. The latter plant is the chief food.

The **pupa** is erect and girdled.

One of the "yellows" is the "bordered sulphur" (*Terias smilax*), a small, delicate-looking insect, 1¾ inches across the wings. The upper surface of wings is bright sulphur yellow, bordered with dusky brown; under side is yellow. **Larva** is green. Food plant: found feeding on *Cassia fistula.* **Pupa** is keel shaped; erect and girdled.

Waterhouse and Lyell say: "This, the smallest species of the genus, is the most widely distributed, ranging from Victoria to Cape York and Darwin. It has migratory habit, though in lesser degree than in *teutonia* and *pythias.* We have records of a flight in the Blue Mountains lasting from 21st April to 4th May, 1906, and of a smaller flight at Gisborne lasting five or six days in October, 1894. The direction of the flight was north to south in the Blue Mountains, but from east to west in Gisborne."

FAMILY PAPILIONACEÆ.

(Swallowtails.)

These butterflies are noted for their beauty and size. In some species the hind wings are prolonged into lobes or tails—hence the term "swallowtails."

Characters: (1) Larva usually has a forked, retractile tentacle just behind the head. When ejected, this may emit a rather disagreeable odour. (2) The pupa (Plate 35, Fig. 7) is attached by the tail in an upright position (Plate 35, Fig. 5); it is girdled. (3) The hind wings have the inner margins concave, and lobes or tails are often present.

Type: Orchard Swallowtail (*Papilio aegeus*). This is found in the spring and to the end of autumn. The sexes differ. The female has fore wings of a general dusky grey, which darkens as it approaches the body to a black colour. The hind wings are dusky black near the body, then a white area, and lastly a velvety black with patches of orange and fewer blue areas: there are seven red lunules around the margin. The male is of a velvety black colour, with a narrow cream patch on fore wings and a large cream patch on each hind wing: there is a red lunule just opposite the tip of the abdomen.

The eggs are deposited singly on the surface of the leaves of the citrus plants. The larva

when full grown is over 2 inches long and olive green in colour, with flecks of darker green and white and a patch of white on the head. It has a retractile magenta-coloured forked tentacle near the head and, when extended, this emits a curious odour suggestive of decayed citrus fruit. The larvæ are often parasitised.

The **pupa** is erect and girdled; it is pale green, fawn, or brown. If obtained up to late summer the adult emerges, but if later than March it usually remains as a pupa all winter and as late as November.

A smaller type and resembling the former is another orchard swallowtail, *Papilio anactus* or "dingy swallowtail." The fore wings are of a smoky brown colour, with patches of white: it has the same number of red lunules on the wings as those of *aegeus*. The larva is a bronze green in colour, flecked with pale blue and yellow. Food plant: citrus trees, chiefly lemon. We obtained several pupæ. The pupation of these larvæ, which in summer takes about an hour, may take two or three days in the winter. So slow was it that we thought some of our larvæ were dead. After the end of the body was secured by the patch of threads and the girdle formed, the caterpillar hung in this way for two days, when the larval skin burst and was pushed off. We made observations on about a dozen in all; two made no girdles, but just hung downwards, suspended by the tail.

"The blue fanny" (*Papilio sarpedon*) is a very pretty black butterfly with the central portion of wings a bright turquoise blue.

The **larva** is a bright green caterpillar spotted with yellow, and on the thoracic segments are long, fleshy tubercles; tail forked. It feeds on the camphor laurel.

The **pupa** is elongate triangular; the tail forms the apex of the triangle. It is pale green in colour at first, but darkens later. It is girdled.

"The green fanny" (*Papilio macleayanus*) is very similar to the former, but smaller and with pale green markings.

Food plant of larva: camphor laurel, *Prostanthera*, *Sassafras*.

The "bird-wing" *Papilio* (*P. richmondius*) is the largest butterfly in New South Wales. It is found on the Richmond River, and its range is north of the River Clarence. It is called the "trogan" on the Northern Rivers.

The sexes differ markedly. The male measures 5 inches across the wings. The fore pair are a rich velvet black, with a band of brightest green near the margins; the hind wings are a rich emerald green with black patches. The female is of a dusky black adorned with patches of dull white on the fore wings and a few yellow patches on the hind pair

FAMILY HESPERIDÆ.

(Skippers.)

This group is so named because of the skipping method of flight of the adults. These butterflies are among the small and medium sized. Brilliant colours are absent.

Characters.—The larva has a large head followed by a narrow neck-region. The body increases in size towards the centre and tapers towards the tail. Usually smooth; in a few cases sparsely covered with hairs.

Pupa (Plate 35, Fig. 6) is elongate, attached by the tail to the surface of a leaf, and the leaf is often curled, or several leaves are fastened together by threads and the larva pupates in this shelter. By some authors this group is regarded as a type between moths and butterflies, its general structure and flight being of the butterfly habit, while the sheltering habit and the thickness of the body suggests the moth habit.

The bodies of the adults are thick and strong; head is large, antennæ wide apart and terminating in elongate clubs with slightly curved hooks. The flight is quick and strong.

Type: The banded skipper (*Erynnis sperthias*) is one of the largest skippers, but as far as butterflies go, it is small. The male has wings of brown and gold. The female is bright brown, with dull yellow blotches.

The eggs are deposited singly on under surface of various species of palms. We have found the larva concealed near the tip of the leaf, the edges of which it had drawn together. It remains in this shelter in the day, and comes out to feed at night.

The head is produced into a structure which reminds one of the turban of a hindoo.

Pupa: It pupates between the edges of leaves.

MOTHS.

SUB-ORDER—HETEROCERA.

Characters.—(1) The antennæ are varied in form, but are not clubbed at the tip as are butterflies, except in a few cases (Plate 36, Fig. 5.) (2) The division between the thorax and abdomen is not strongly marked. (3) The colours are more sombre than those of butterflies, and moths fly more usually at night. (4) A **frenulum** (Plate 39, Figs. 5 and 6) or bunch of strong bristles (in female usually), or a spine (in male) is borne at the base of the hind wing on the front edge in most moths. It helps to keep the wings on one side together, so as to act as one large wing.

Moths are more numerous than butterflies. Most species have the long sucking mouth (Plate 38, Figs. 5, 6, 7). Some of the worst pests to man are in this group. The silkworm is a source of wealth for the silk woven from the silken cocoons.

We shall notice some of the familiar moths.

Family Sphingidæ—Hawk Moths (Plate 36). The scientific name was given owing to the habit of the larva, when resting, of drawing up its head and the fore part of its body in a peculiar manner, giving it a sphinx-like appearance. The term "hawk" is used probably on account of its keen, swift flight, its clear-cut wings and body, and its habit of poising over the flower when extracting nectar.

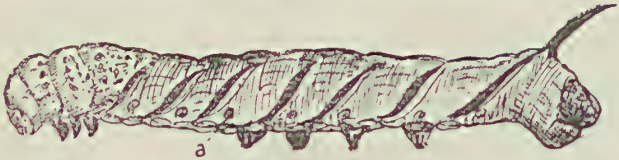


Fig 1 Larva. a. Spiracle

Fig 2. Pupa a. Tonque-tube

Fig 3. Adult

Life History of Hawk Moth (*Protoparce*)

Fig 4 Wing scales (magnified)

Fig 5. Types of Antennae (Enlarged)
a Plumed . b. naked c pectinate

Hawk moths vary in size from medium to large. They fly at dusk and in the night. The general colour is from grey to brown; the hind wings are often of bright colour. The moth is adapted for swift flight by its rather pointed head and body. Its eyes are large and keen, and it has a long proboscis: we measured the tongue of *Protoparce* and found it was 4 inches. These moths visit and cross-pollinate long-tubed flowers such as the *Bouvardia*, and the moon flower (*Ipomoea bona nox*), etc.

The larvæ (Plate 36, Fig. 1), are smooth and are often ornamented with transverse oblique bands of yellow or white, and more rarely with eye-spots. There is a prominent terminal spine usually present on the upper part of the tail These larvæ are pale green in colour to blend with leaves, or they may be brown. When about to pupate in the earth, the pale green colour becomes blotched with fawn or brown, and this protects the larvæ when crawling on the ground. The pupa is curious in many species, by having the mouth parts enclosed in a case which is quite free from the body, except at the basal point of attachment to the body (Plate 36, Fig. 2 a). This mouth case is bent or coiled under the head. In captivity, some larvæ did not trouble to go under the earth, but pupated on the surface, and one partially enclosed itself in a silken cocoon; in this case the lid was on the box and provided a measure of darkness.

Types.—The privet hawk moth (*Sphinx ligustri*) The convolvulus hawk moth (*Protoparce convolvuli*), whose colour is of a general mottled grey and

brown, with pink patches on the abdomen. The larva feeds on convolvulus and sweet potato. The silver striped hawk moth (*Chaerocampa celerio*), whose fore-wings are greenish black, with silver lines from the tip inwards. The hind wings are marked in pink and black. Then there is the grass hawk moth (*Chaerocampa scrofa*), whose dull brown larva feeds on grass. The moth is brown, with hind wings of brick red. The genus *Caequosa* contains the giants of the hawk moths—one species measures 7 inches across the outstretched wings. The larvæ are covered with rough tubercles: the terminal spine is absent. At the anal end of the body are two spots resembling eyes, and these are more prominent than the eyes, and would lead one to think the head was at this end.

The caterpillars, when reared in captivity, did not pupate in the ground, but drew leaves of the food plant together with silken threads and pupated in these.

Food Plants:—Native honeysuckle (*Banksia*), geebung (*Persoonia*), and some of the wattles (*Acacia*).

The caterpillars feeding on *Banksia serrata* are most difficult to detect owing to the blending of colour; for the leaves of the plant have a strongly marked light-coloured midrib, and the larvæ place themselves in line and can hardly be seen. A few of the hawk moths have clear scaleless wings. We examined the wing of *Protoparce* with the lens and sketched the frenulum on the hind wing (Plate 39, Figs. 5 and 6.)

FAMILY PSYCHIDÆ.

(Case Moths.) (Plate 37.)

These are moths whose larvæ live within silken cases, either with pieces of stick, leaves, etc., attached or just a more or less smooth case. In walking, the caterpillar has only the head and 3 pairs of horny legs without the case, and this part of the body is consequently hardened, and is much darker in colour than the rest of the body which is protected by the case. It drags the case along as it walks.

The method of constructing the case is worth observing. We reared some larvæ of the large case moth from the egg. At first they resembled tiny black threads, but when they moved we saw that each had a slender web attached to itself. The spinning commenced at once, till a tiny bag was made. This increased in size, but the larva worked along the upper edge, much as one proceeds in knitting a sock. The growth of the case keeps pace with the growth of the larva. The upper edge is always loose, so that it can be attached to any object. To strengthen the case, pieces of sticks, leaves, pine needles, etc., may be woven in. Everyone has noticed these case moths and the wonderful arrangement of the "sticks" or leaves. The inside of the case is smooth and silky. If the caterpillar be placed in a box with a glass lid, one

Fig 1 Caterpillar partly within case.

Fig 2 Caterpillar free from case

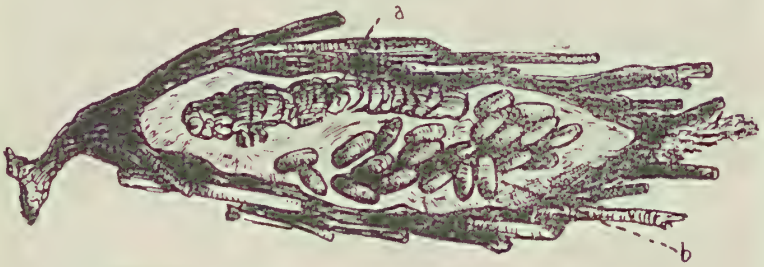


Fig 3 Case slit to show - a shrivelled larva
b. fly cocoons (parasites)

Fig 4 Faggot case moth

Fig 5 Leaf case moth
a pupa of male

Fig 6 Ribbed case moth

CASE MOTHS.

will soon see regular transverse lines of short silken threads, not unlike railway sleepers, all over the surface of the glass. These are the "foot-holds" of the caterpillar to enable it to move over the smooth surface of the glass. It does it so quickly that one can hardly see the placing of these threads.

The larvæ pupate within the case, and then a beautiful, soft, white, silky "blanket" is made to protect the pupa. The female never leaves the case—she is wingless and lays the eggs within it. The male emerges from the end of the case, the pupal shell being pushed right out, and hangs from the tip of the tail of the case.

The male moth is winged and is not very conspicuous. The tiny larvæ let themselves down from the case by long silken threads.

Metura elongata (Plate 37, Figs. 1, 2, and 3) is the largest case moth, the larva which forms a very large case, with pieces of stick sewn in, is of orange brown and black colour. There is the faggot case, leaf case, and the beautiful little ribbed case. The "moths" are popularly named from the type of case woven by the larvæ. (Plate 37, Figs. 4, 5, and 6.)

Interesting experiments can be made to show the weaving powers of the larvæ. We cut the case of *Metura* from end to end. Almost instantly the larva drew it together at the upper end; then it wove the edges so neatly and so closely that it was hard to detect where the incision had been made. It is curious, too, to find that there are careless individuals who just cobble their cases together; we came across this three or four times.

Another time we made a case of flannel in the form of the *Metura* case. We removed the larva from its own case and left it overnight. In the morning we found it was comfortably within the flannel case. Then we placed its own case back again. It vacated the flannel one and went back in its own case. We split open the flannel case, and found it was lined with a layer of silky threads.

Parasites: These caterpillars are frequently parasitised by flies and wasps, in spite of the protection of the case. The eggs are laid, and the larvæ (maggots) feed on the juices of the caterpillar, and finally spin little brown cocoons, which are frequently found beside the remains of the victim within the case. (Plate 37, Fig. 3.) We have found in nearly every instance the parasite is a tachinid fly. In one large *Metura* case we counted 130 pupal cases of such flies.

The *Metura elongata* has a very long existence as a caterpillar — a year, and they can live without food supply for months. They are sometimes a serious pest in orange orchards, for they eat quickly and largely. The food is varied, not being confined to one or few plants.

FAMILY LIPARIDÆ.

(Tussock Moths.)

The caterpillars are thickly clothed with tussocks of hair, which give them a woolly appearance. Children sometimes call them "woolly bears." The usual colour of the larvæ is brown, with markings of either yellow or red or blue. They feed on a variety of plants. We have seen plants of potatoes, etc., reduced to mere stems by numbers of these larvæ. On one occasion we saw quite an army of them cross the road from one devastated potato patch to the adjoining field. However, most of these caterpillars are solitary in habit. The pupa is enclosed within a loose, bag-like cocoon, and often the hairs from its own body are interwoven. We have seen these caterpillars turn and pull out some hairs and work them into the threads of the cocoon. The moth is of medium size, and the female is often wingless; she then just crawls out of the cocoon and lays the eggs on the threads of it.

Types: *Darala ocellata* is light yellowish brown marked with black. The larva feeds on grass, and makes a soft yellow cocoon similar to that of a silkworm but looser, and with hairs from its own body standing out like bristles. The female is wingless.

Teara is a genus whose larvæ travel about in armies and are hence called "procession moths." They form "shelters" of leaves sewn together, and the army of larvæ take shelter within in the day; these bags are often seen in a fork of a branch. They feed at night, and may proceed in single file or in rows. We have amused ourselves with turn-

ing the leader off and watching the result of the procession. They pupate in the ground, and spin there the silken cocoons.

There is a giant tussock moth, *Chelepteryx collesi.* The caterpillar of reddish brown is armed with stiff bristles, which give it a formidable appearance, and these bristle-like hairs are a weapon of defence, for they have an irritating effect on the skin. Mr. C. H. Wickham, in "The Australian Naturalist," records: "The caterpillar feeds on eucalyptus leaves at night, resting by day on the bark, where it is inconspicuous. They sometimes grow to a length of six inches. The irritating brown hairs are readily shed, and constitute an effective defence against molestation. When pupating, the caterpillar presses its back against the silky cocoon, causing hairs to protrude right through, in which position they remain when the larva withdraws its back. The sides are then treated in the same way. The cocoon is thus thoroughly protected. (Plate 39, Fig. 4 a.) The larvæ are found from November to January, and the pupal state lasts for 150 to 160 days."

The tussock moth larvæ, or "woolly bears," are frequently parasitised by braconid and ichneumon wasps; such females usually have a long, slender ovipositor, which reaches down among the hairs and places the eggs in the body of the victim. The wasp maggots, when ready to pupate, make their way out of the living but weakened caterpillar, and spin little white cocoons on or near the victim, which then dies. Sometimes a cocoon is found full of these tiny white wasp-cocoons.

FAMILY BOMBYCIDÆ.

(Silkworm Moths.)

As the name suggests, the cocoons of these moths are spun with abundance of silken thread.

Most children know our commonest type, the emperor gum moth (*Antheraea eucalypti*). (Plate 38.) The colour ranges from a light fawn to salmon pink and brownish fawn, and there is a prominent eye-spot in each wing. The male is smaller than the female, and can be easily distinguished by the beautiful feathered antennæ. The female has a thicker body, and the antennæ are "combed," but not plumed like the male.

The eggs are laid on or near the plant. The tiny larvæ are dark in colour, but as they develop change to a beautiful pale sea-green colour, almost transparent along the back, where the blood may be seen passing along the main blood-vessel. Each segment bears a set of tubercles, from which groups of tiny spines project; the terminal segment bears one larger tubercle than the rest. (Plate 38, Fig. 2.)

Food plant is the eucalyptus, and we have noted in some cases that if the caterpillars have been feeding on a particular species of gum-tree they will starve rather than feed on a different kind which we have supplied. They are frequently found on "pepper-trees." On one occasion we found one of the larvæ on a privet bush, and we watched

Fig 3 Cocoon

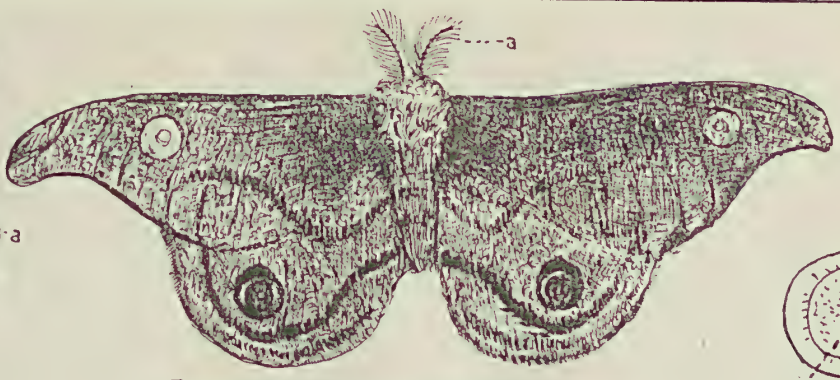


Fig 1. Emperor Gum Moth (Male)
a. Plumed Antennae.

Fig 4. Pupa.

Fig 7. Cross section of Proboscis (After Comstock).
a Supporting Tissue
b & c half tubes

Fig 5. Sucking Proboscis of Peacock Moth.

Fig 2. Larva

Fig 6. Proboscis of Hawk moth (Rolled up)
a. Proboscis.

EMPEROR GUM MOTH AND PROBOSCIS OF MOTHS.

it strip leaf after leaf from the branch. These caterpillars are very interesting types for children to watch, and, when placed in a box, the pupation of the caterpillar is most eagerly watched and enjoyed by most children. Also we have seen children greatly excited over the emergence of one of the adults, for these moths give long warning of their approaching exit by the "scrape! scrape! scrape!" as they cut their way through their rounded, tough, smooth cocoons. (Plate 38, Figs. 3 and 4.) A moth takes some time to cut its way out, and it scrapes for a time, and then rests, and one could easily imagine one had a mouse in the room until searching produced a box with a forgotten cocoon within.

Another type is the "long-nosed wattle moth" (*Bombyx nasuta*), so called on account of the pointed projection on the front of the head. It is a reddish-brown moth. These caterpillars show a fine example of protective colouration, for we found one on the stem of *Acacia baileyana* (Cootamundra silver wattle) and hardly realised that just below were three others. The cocoon is white and silken.

Pinara despecta is terra-cotta in colour, and larvæ feed on gum-leaves. The cocoons are pink and silken.

The silkworm of commerce is *Bombyx mori.*

FAMILY LIMACODIDÆ.

(Cup Moths.)

The name "Cup Moth" is given owing to the cup-shaped pupa. These moths are only medium-sized, and are not familiar. We have found them on low bushes.

The larvæ are more like slugs than caterpillars; the legs are but rudimentary, and seem to be useless, for the body is moved by a series of undulations, like a snail. The centre of the back is depressed. At each end are tubercles, which bear retractile tentacles in circular rows or clusters (these look like little sea anemones). The pain from these spine-like tentacles is very severe, and lasts for hours. We have noticed that the larvæ take up a position on the lower surface of the leaf and work along the edge, bending a kind of lip over the upper side, so that this is all that is really visible from above. Most of our specimens were taken from young gum-bushes in February and March. One species, *Apoda xylomeli*, we took from the waratah in early summer. The larva is of a bright green colour, with a long, narrow yellow line down the middle of the back. When resting it often places itself in such a position that this yellow band is in line with the midrib; it is most difficult to detect the caterpillar: this is a very fine example of protective coloration.

Life History of the Mottled Cup Moth
(*Doratifera vulnerans*).

Measures about one inch across the wings. The colour is shades of marbled brown; the hind wings are creamy brown.

The eggs are deposited on leaves of gum-trees, and we have found them on those of apricot-trees. The caterpillar is broad and about an inch long. The hollow in the centre of the back is prettily marked with orange and purple-grey. The raised parts at each end are ornamented with red tubercles bearing clusters of creamy spines. It is difficult to distinguish the head from the tail.

Pupa: We observed the pupation of the larva. It chose one of the gum-twigs in the box, and it vigorously ate the bark away. After an hour at this occupation, it rested an hour; it then stretched itself along the twig. We watched the following process with a lens:—It bent its body back, first on one side and then on the other, till it touched the twig behind its back, and at every turn a thread was fastened on to the twig. This was done with great rapidity. Some were fastened to another thread. This continued till a flimsy cover was formed. Then the larva brought both ends of its body together, the under surface being outwards. Now the doubled-up caterpillar moved round as a whole, according to the position required to build up its cocoon. Hour after hour we watched, till the cocoon began to assume the oval shape. When it was almost opaque we could detect the head of the caterpillar working in a circle at the upper end, which was slightly smaller than the base. To us it seemed to be putting an

extra thickening layer round this part. It pressed its head continuously against the inside, until the little structure bulged slightly at the top; and later it was a darker colour than the rest of the cocoon, and we realised we had seen the operation of the making of the "cap" of the cocoon, which the emerging adult pushes off. We watched this performance for 13 hours, and yet not till two days later did the cocoon assume its natural greyish-brown colour. Could we have continued to view the inside of the cocoon we should have found that the caterpillar remained in its larval state for weeks, or perhaps months, before it pupated.

Another larva under observation made its cocoon just where the lid of the box in which it was placed fitted over the box, so that when we opened the box part of the cocoon was torn away with the lid. Almost immediately the larva set to work and put a patch over the tear by spinning the threads over and over till the rent was made whole.

Another cup moth is *Limacodes longerans*, "the painted cup moth." The larva feeds on the leaves of *Eucalyptus*. The cocoon is perfectly elliptical, and resembles a bird's egg, for the upper end is not outlined with a cap. One of these caterpillars we had in a box erected a scaffolding of threads across the corner, and then made its little cocoon, resting on the bottom of the box but away from the sides; it was supported laterally by these "scaffolding" threads. Shortly after the cocoon was finished the threads broke away, and the cocoon stood free. We found that this pupa was parasitised by little black wasps. One wasp was out in the box, and six others were ready to emerge.

FAMILY TORTRICIDÆ.

(Leaf Rollers or Bell Moths.)

The former name is popularly applied on account of a leaf-rolling habit developed by some larvæ, whilst the latter arose from the bell-shaped outline assumed by the perfect insect when at rest. Many of the larvæ display a decided liking for the seeds of some fruits.

The codlin moth (*Carpocapsa pomonella*).—With this moth perhaps few people are familiar, but in the caterpillar stage it is known to all. It measures scarcely more than three-quarters of an inch across the wings. The front pair are greyish-brown and the hind pair almost cream in colour. When at rest the bell shape is very distinct.

It first appears during September or October, and deposits its eggs singly on the leaves of the apple-tree. Later some eggs are placed in the blossoms in front of the calyx and behind the petals, just when the latter are about to fall off. The larvæ hatch out in any time under a fortnight; those on the leaves generally make their way immediately to the calyx end of the forming fruit The calyx soon closes up over the tiny grubs, which then bore directly into the fruit, making for the core and the pips, on which they feed.

When full grown the larva may be nearly an inch long, with a tiny reddish head. But it is not going

to pass the remainder of its life in the fruit; so it eats a tunnel to the outside of the apple, and then finds its way down to the rough bark of the tree, or perhaps to the ground. If to the latter, it soon gets back to the tree, where it possibly rests in a crack of the bark and covers itself with dense, cobweb-like felt, under which cocoon it casts its skin and changes to the pupa or resting condition, remaining thus from one to three weeks, when the pupal cover is cast off and the moth appears. The second brood of moths lay their eggs on the leaves, twigs, or even on the half-grown apples; a favoured spot seems to be where a leaf or another apple is touching. The larva at once eats into the fruit. The pupæ from this brood often hibernate, and thus give rise to the moths of spring. Quinces and pears may be attacked in a similar way to the apples. A spray of arsenate of lead has proved an effective remedy, 2 lbs. of lead being mixed with 50 gallons of water. The lead will remain a considerable time in suspension in the water, and does not easily wash off. In New South Wales it is compulsory to spray trees three times within nine weeks from the fall of the petals. The spray is a very fine one, and the first spraying is directed particularly to the flowers just after the petals fall and before the calyx has closed over, so as to poison the tiny grub, which so generally makes for the calyx end of the fruit.

A fold of hessian or an old bag is often tied around the tree in such a way that one part falls over the other. The larvæ which reach the earth,

in crawling back to the tree, find a convenient shelter under the hessian, and there pupate. This bandage must be carefully watched, taken off at regular intervals, and the grubs or pupæ under it crushed and the bandage re-tied. If this is not done, it might form a breeding-ground for the pest instead of acting as a preventive measure.

The cherry-tree borer (*Cryptophaga unipunctata*) The larva of this moth bores holes and lives in the stems of the pear or cherry tree. The tunnel acts as a shelter by day, but at night the caterpillar comes out and feeds on the leaves. It pupates in the tunnel. The moth is a soft, creamy-white insect measuring about 1½ inches across the outstretched wings. The only ornamentation is a black spot in the centre of the front pair.

FAMILY AGARISTIDÆ.

(Day Moths.)

These moths fly freely in the daytime, and are often mistaken for butterflies, for their colours are usually bright and their flight quick and strong.

One of the commonest is the vine moth (*Phalaenoides glycine*). It is a black moth with lemon-coloured patches on the wings; the tip of the abdomen has a cluster of orange-coloured hairs. The eggs are tiny, pearly bodies, and may be deposited in a cluster on the stems of the food plants (grape vine and virginia creeper). We have noticed this moth laying eggs singly on the leaves of the grape vine. The young larvæ emerge in the springtime, when the young leaves begin to come out. The larva is a very strong caterpillar, and eats rapidly; it is greenish-brown speckled with yellow and having a red band near the tail end. It seems to be partial to fuchsia.

Arsenate of lead is an effective spray to kill these pests.

The larva pupates in the soil, where it makes a shelter by cementing particles of soil or dead leaves by means of a sticky secretion. A caterpillar placed in a cardboard box just nibbled pieces of paper off and formed a cocoon of these. Another time a caterpillar was placed in a box with some galls, one of which had a large opening at the end;

we found later that the caterpillar had retired within the gall and just sealed the end. Again, we have had larvæ pupate in a box without troubling to make a shelter.

If the weather is warm, the adult may emerge in 14 to 21 days. Sometimes these are hard to rear. The larvæ are very strong, and the lid of the box needs to be very secure to keep them prisoners.

Another type is the "painted day moth" (*Agarista agricola*), so gaily coloured that it is more often taken for a butterfly than a moth. The general colour is black, with patches of orange, and pale blue and red markings. The larva is equally gay in colour—black and white, with orange bands.

Food plant is the "wild grape vine." We placed a larva in a box with grape vine leaves, and it ate them with seeming relish. It pupates in the ground, and when confined in a cardboard box or match-box will tear off pieces of this and form a cocoon

FAMILY NOCTUIDÆ.

("Cutworms.")

"Cutworm" is an appropriate name given to this group, for the larvæ attack the stems of seedlings, cutting them through. There are numerous species, and all are serious pests to growers, for they destroy seedlings of garden plants, vegetables, and young succulent field crops. The caterpillars are smooth, varying from brown to green in colour: some feed in the daytime, others at night. We had some fine young seedling stocks, of which nothing remained but a part of the root. On going out at night with a lantern, the pests were discovered and destroyed. The members of the family *Cruciferae* (stocks, cabbage, turnip) are favourite foods of these pests. Some pupate in the soil; others form loose silken cocoons.

The moths are of medium size, and at times appear in great numbers. They are usually dark in colour, with bright, shining eyes; and from this latter fact the name *Noctuidae* (from *noctua*, an owl) has been given to the family.

The bugong moth (*Agrotis infusa*) measures about 1½ inches across the wings. The front pair are almost oar-shaped, dark brown in colour, with wavy parallel lines running across them, and further ornamented on the central portion with black and grey markings. The hind pair is light brown,

It received its name from the Bugong Mountains, where it appeared at one time in countless thousands. Such abnormal numbers were noticed about Sydney in 1905, when the inside walls of many public buildings were literally black with them; particularly was this so in many of the churches of the Illawarra suburbs. The same year, in the Maitland district, these Bugong moths were met with on the farming land in innumerable companies, apparently having just emerged from the pupal state. The quantity of eggs deposited by these insects is enormous.

The bean moth (*Plusia verticellata*) is perhaps more familiar than the Bugong moth. It measures 1½ inches across the wings. The front pair is of a bronze tint, marbled with silver and purplish grey; the hind pair is brown edged with a slightly lighter-coloured fringe. The moths may be found during the daytime hiding among the leaves of beans, peas, or potatoes. If these plants are shaken, quite a number of the insects will fly up; then if the under surfaces of the leaves are examined, one is almost certain of finding the tiny eggs attached to them.

The pale green larva, which tapers toward the head, assumes somewhat the form of a "Looper." Three pairs of walking legs are present—two pairs of prolegs and a pair of claspers. When it is about to move forward it holds on to the plant stem by the abdominal legs and claspers, then lifts its head and fore part of the body, much as an elephant does its trunk, and feels about in the air

as if to be sure of its next move. When satisfied that the way is clear, the object ahead is grasped by the walking legs; then the remainder of the body is pulled up in an arch or loop. It pupates in a loose cobweb-like mass on the under surface of the leaves of the food plant.

The bean moth has a very close relative in *Plusia argentifera*, which has similar markings on the wings, which are generally of a lighter colour, the hind pair being opalescent. The larva, too, strongly resembles that of the bean moth, and we have found it on the same food plants.

The army worm (*Leucania unipuncta*).—Like an army, countless numbers of the larvæ attack various types of vegetation, often leaving nothing but the stems of the plants attacked, and sometimes not even these. They are nearly 1½ inches in length, dull green in colour, with lighter stripes running along the body. They pupate in the soil. The moth is a light brown or buff in colour.

Poisoned bait has proved one of the most effective remedies for the cutworms. One oz. of paris green, 1 lb. bran or pollard, mixed dry, then water and a little salt added. Pellets of this scattered among garden plants or growing crops form a most attractive bait.

FAMILY GEOMETRIDÆ.

("Loopers.")

The name is given because of the looping or "measuring" movements of the caterpillar. The adults are small to medium size, with colours ranging from dark brown, grey, to pale green. The wings are often marbled, and this blends in most markedly with the medium on which the flat wings of these moths rest. It is hard to detect these moths on posts or walls.

The **larva** advances by looping movements. The head is thrust forward, and the remainder of the body is looped up, bringing the tail near to the head; then the head is pushed forward again. This is necessary because there are only two pairs of fleshy legs instead of four. These larvæ also exhibit great muscular control; they stretch themselves and remain rigid, resembling either brown or green twigs. They can be captured by shaking a branch over an open umbrella.

Fig 1 Larva (wood borer) (*Zeuzera*)

Fig 2. Pupa a - Bristles.

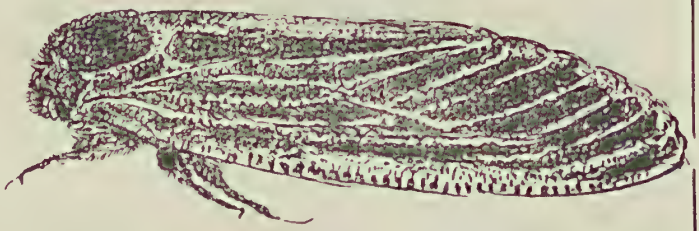


Fig 3 Adult. (*Zeuzera*)

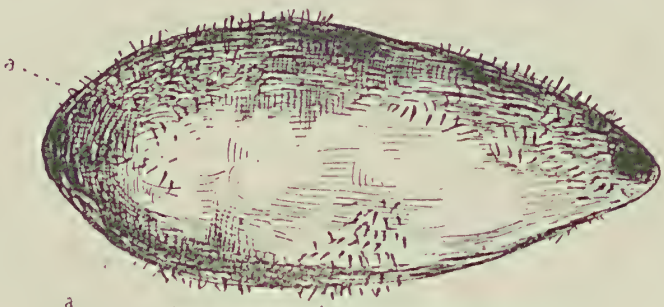


Fig 4 Cocoon of Bat-moth (Chelopteryx)
a Larval Spines

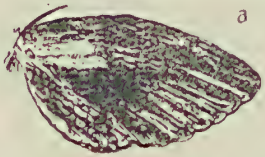


Fig 5 Hind wing of Hawk-moth showing frenulum
a Frenulum

Fig 6. Frenulum (enlarged)

MOTHS.

FAMILY HEPIALIDÆ.

(Wood Borers.)

These moths are noted for their size and beauty The larvæ are wood borers, and many of them are 3 inches or more in length and very thick. They are cream-colour, due to their protected life in the wood. (Plate 39, Fig. 1.) The eggs may be deposited on the trunk, and the larvæ feed at first on the bark and then bore into the trunk. They pupate in part of the passage formed from their tunnelling. Often there is a web-like covering to hide the entrance to the tunnel of the larva. These grubs are said to be used by the blacks as bait for fishing.

One of the common wood-boring moths is *Zeuzera eucalypti.* (Plate 39, Figs. 1, 2, and 3.) This is a large, thick grey moth, with wings marbled with black and brown. The scales are rather sparse and easily rubbed off. The wings droop close down the side of the body in repose. The pupa is interesting, having on the abdomen rows of tiny spines on each segment edge, and these aid the pupa to push along in the tunnel to get to the opening for the moth to escape. (Plate 39, Fig. 2a.)

Another type is the Bent-wing Moth (*Leto stayceyi*)—a handsome fawn, with brown and black marbling; eye-spots are present on fore wings.

FAMILY TINEIDÆ.

(Clothes Moths.)

These are the small cream moths so familiar in the house. The moths lay their eggs in woollen material which is stored in dark places, such as drawers, cupboards, or if just left hanging for some time in wardrobes. Carpets, furs, and blankets are favourite materials for eggs to be deposited in, and cotton wool left in boxes of specimens has been attacked. The larvæ may make little tunnels of the material and live in these, and later on pupate in them. Other species move more freely and carry a tunnel along with them. Others, again, spin no tunnel, but just make a web-shelter in which to pupate.

"Moth balls" or naphthaline balls are effective in keeping away moths. We have also found that wrapping articles in newspaper or in unbleached new calico is effective. A friend informed us that for many years she has hung a small tin with a perforated lid, after being filled with cotton wool saturated with turpentine, in her wardrobe, and it has been quite free from moths.

FAMILY PLUTELLIDÆ.

This family is mentioned because it contains one of our most destructive vegetable pests—the cabbage moth (*Plutella cruciferarum*), a small insect measuring about 1¼ inches across its narrow outstretched wings. It is light fawn in colour, with darker triangular markings near the inner edge of the front wings. When these are closed the moth has a roof-like appearance, and the triangles of each wing, meeting, form a rectangle; from this fact it is frequently referred to as the "diamond-backed cabbage moth." We have noticed it wherever plants of the *Cruciferae* family (cabbage, cauliflower, turnip, stock) were grown. Upon the leaves of these plants the tiny eggs are deposited. The slender, delicate-green caterpillar, less than three-quarters of an inch in length, eats holes in the leaves and then pupates under a loose silken web which it attaches to their under surface.

Our experience in following the life history of this moth proved that it occupied about 14 days from the egg to the perfect insect.

In the vegetable garden where cabbages and turnips grew side by side, the former always seemed to have the preference as a food plant for the larvæ. Stocks growing but a few yards distant were riddled to such an extent that there was not a chance of their recovery. Two or three years in succession we have noticed what seemed to us a decided preference for stocks over the vegetables of the same family.

Experienced vegetable-growers recommend the dipping of plants in tobacco water for a short time before setting them out. This destroys eggs that might be already on the leaves. Tobacco dust and lime may also be sprinkled freely over young plants. Paris green is frequently used as a spray.

ORDER DIPTERA.

(*dis*, two; and *pteron*, a wing)

This order includes many very serious pests, though there are some useful types found in it. The adults resemble somewhat the hymenopterous insects, but can be distinguished from them by having but **two** wings, while the hymenopterous insects (bees, wasps, etc.) have four.

Mosquitoes, midges (mosquito-like insects), and flies are included in this order, and some authorities include fleas, while others place them in a separate order called **Siphonaptera.**

Characteristics of Order Diptera.

The two **wings** are borne by the metathorax; they are membranous and are usually much veined and naked, though the midges have microscopic hairs and mosquitoes have modified hairs in the form of tiny scales which are attached to the veins of the wings. (Plate 41, Fig. 8.) These are very tiny, and do not make the wings opaque, as in the wings of moths and butterflies. In place of the hind wings there is a pair of knobbed processes called halteres or balancers. (Plate 40, Fig. 9, Plate 41, Fig. 3 a) Their use is not fully understood, but it has been suggested that they act as balancing organs, or as "rudders" to steer the insect in flight. They are attached to the metathorax. At the base of the wing is a lobe called an **alula** (Plate 40,

Fig 1. Eggs

Fig 2. Larva.

Fig 3 Cocoon

Fig 4. Sucking Proboscis
a Lip

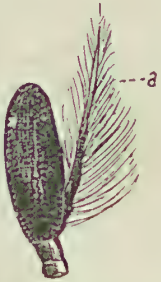


Fig 5. Antenna.
a. Plumed bristle.

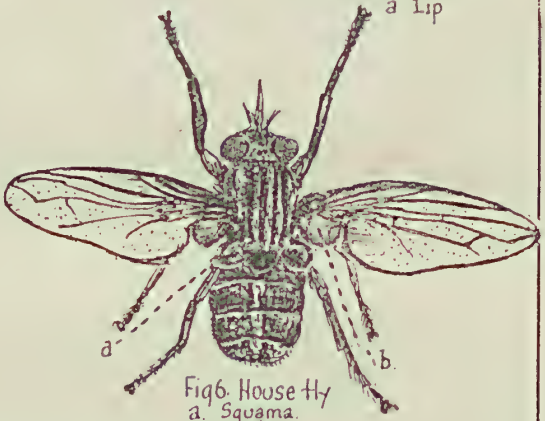


Fig 6. House fly
a. Squama.
b. Alula.

Life History of House fly (Musca Domestica)

Fig 7. Types of Antennae
a. Midge
b. Robber fly
c. March fly.

Fig 8. Pupa.
(Larval form)

Fig 9 Haltere.

FLIES.

Fig. 6 b), and in a group of flies there is a little winglet called a **squama** (Plate 40, Fig. 6a), which is at the very base of each wing, and which may cover or partly cover the halteres. The house fly and blow fly have well-developed squamæ.

The **thorax** is very solid and all in one piece—that is, one cannot easily distinguish the three thoracic segments.

The **head** is usually well separated from the thorax, and can be moved freely. The **eyes** are very large, and in most male dipterous insects meet, forming the greater part of the head. The eyes are compound, being formed of numerous facets, which may vary in size according to their position. It is the efficiency of these eyes that makes it fairly hard to catch most flies. Three small **ocelli,** or single eyes, are also present.

The **antennæ** are of three types—two widely differing in form (1 and 3), and an intermediate type (2) linking the two extremes. (Plate 40, Figs. b and c.) The first type is the **plumose,** with whorls of longer or shorter hairs. These can be seen in gall gnats, midges, and mosquitoes. (Plate 40, Fig. 7 a.) The third type is curious. There are usually only four segments. The three basal ones are more or less solid, the fourth and upper joint (which is probably formed by the fusing of many smaller joints) is produced in the form of a **bristle** or **arista.** In many flies, such as the house fly, stable fly, fruit fly, the third joint enlarges and by unequal growth forms a thick, rounded-oblong segment or lobe, and the bristle is reduced

to a position at its base instead of retaining its terminal position. (Plate 40, Fig. 5.) The intermediate type (Plate 40, Fig. 7 b and c) varies; it may have fewer joints than the plumose type, and usually tapers to a point. Example, the robber fly (*Asilidae*).

The **mouth** (Plate 41, Fig. 1) is very variable, but it is formed for suction and not for biting and chewing. Most usually it consists of six elongate bristles or stylets, and these can be placed in a sheath, which is a pseudo tube—that is, it is open and simply enfolds the stylets. The whole proboscis can be retracted and placed in a cavity under the head. By means of these stylets, which are placed all together, the medium is pierced and the liquid is drawn up. The house fly and blow fly have a purely sucking mouth. There are no stylets, and the tip of the proboscis is produced into a broad lip. (See Plate 40, Fig. 4.)

Life History.

The **larva** (Plate 40, Fig. 2) is a legless grub—the typical "maggot." It differs from a caterpillar in having no legs and no anal claspers. It is smooth in most cases and a creamy colour. The head of a maggot is very small, and can be withdrawn and hidden. In some groups of flies, the head of the maggot is not clearly defined. The most conspicuous part of the head of the larva is the pair of dark, strong jaws. Many maggots can jump by curling up the body and then straightening it. They feed on vegetable or animal matter, and are often parasitic on living animals, such as

sheep, horses, etc. Dipterous maggots breathe in two ways. Some have the lateral spiracles—along the sides of the body; while others, such as maggots of blow flies, fruit flies, have a pair of spiracles at the head and a pair of plates at the tail end of the body, with three spiracles on each plate. (Plate 44, Fig. 4 a.)

Many dipterous larvæ live in mud or in shallow water, and some of these have an elongation of the posterior end of the body to form a tube (Plate 43, Fig 4 a) which leads to the air, and which enables such maggots to get a sufficient amount of air, for in mud the supply is limited.

In warm weather maggots develop very quickly; indeed, the life history of the house fly from the egg to the adult may be but a fortnight. Their rapid development means an enormous increase, and this makes some types very serious pests.

Though maggots are repulsive to us, associating them as we readily do to the "blowing" of meat in hot weather, attacking sheep, etc., yet they are scavengers which rid us of much disease-carrying matter.

The **pupa** (Plate 40, Fig. 3) is interesting, for in many cases the last larval skin is used as a kind of cocoon, within which the larva pupates, so that in these cases the adult emerges first from its own pupal skin and then has to break through the "puparium" or last larval skin. The **puparium** is in two forms: (a) When the appearance of larval form is retained —example, soldier flies (Plate 40, Fig. 8) and in the "hairy maggot" of the sheep fly the larval

tubercles are retained (Plate 44, Fig. 8); (b) when the puparium shrinks and forms a smooth, barrel-shaped, seed-like appearance—example, fruit flies, house flies, etc. (see Plate 40, Fig. 3). In many cases the pupa is free, having no larval skin present to form a puparium, examples: tipulids ("daddy-long-legs") (Plate 42, Fig. 3), march flies, sand flies, robber flies.

The Order Diptera includes both friends and enemies to man. The tachinids, sarcophids, syrphids parasitise other insect pests; but, on the other hand, there are many disease-producing dipterous insects. The mosquitoes infect man with fever, such as malaria and yellow fever; and house flies carry germs of typhoid, anthrax, etc. The tsetse fly infects cattle with "fly disease," and *Glossina* transmits to man the "sleeping sickness." "Blow flies" cause meat to be unfit for eating, and some species attack the soiled wool and afterwards the flesh of the sheep, the maggots feeding on them. The "bot flies" include serious pests which attack horses, cattle, and sheep. Then the "fruit flies" destroy the orchard crops.

FAMILY CECIDOMYIDÆ.

(Gall Gnats.)

These are very minute flies with wings with few veins. The antennæ are long, with whorls of hairs. The larvæ are plant-eaters, attacking roots, stems, or leaves. Some make malformations on plants, known as "galls." The "acacia gnat" (*Cecidomyia acaciae-longifoliae*) lays numerous eggs in the

flowers of wattles, and galls are formed by the distortion of the pods, making a mass of continuous galls. The well-known "hessian fly" (*Cecidomyia destructor*) attacks the stems of wheat, which weakens them and causes them to bend, and so the "ear" does not mature.

To observe these tiny flies, get a glass preserving jar and put in some damp sand, and in the latter place some sprigs with galls present. Put a piece of muslin over the top of the jar. By cutting open some of the galls the larvæ and pupæ may be seen. Froggatt thus describes some of the Australian gall gnats: "*Diplosis paralis* forms curious little blisters upon the young foliage of *Eucalyptus corymbosa*, dotting the leaves all over with reddish spots with a keyhole-like mark at the apex. *D. eucalypti* aborts the young twigs of eucalyptus into gouty swellings, in which a number of larvæ feed and pupate. There are certain rounded, shot-like galls of the *Eucalyptus*, generally several in number and on the midrib of the leaf, which, on account of the pupal skins always remaining in the holes in the side of the galls through which the flies have escaped, can be easily distinguished from very similar ones that are the work of micro-hymenoptera."

FAMILY CULICIDÆ.

(Mosquitoes.) (Plate 41.)

Characteristics.—Mosquitoes are slender insects with gauzy wings and long projecting **proboscis** consisting of six stylets; these are held in a sheath. The stylets can be placed together, and a puncture is then made with the tips, while the fluid is sucked up—either plant-juices or blood. (Plate 41, Fig. 1.) Thus the mouth of the mosquito is a piercing and sucking apparatus. The **wings** are membranous, and along the nervures or veins are delicate scales which are really modified hairs; there is a fringe of fine, soft hairs on the back margin of the wings. These structures can be seen by placing a wing under the microscope. (Plate 41, Fig. 8.) The **antennæ** are long, with whorls of hairs, which are very long and plumose in the male but shorter in the female. (Plate 41, Fig. 1 c.) **Food:** The female mosquito which we know so well as a blood-sucking insect, is said to be content with vegetable juices should the blood of animals be unavailable. The male mosquito does not attack animals; in some species the male is said to be unable to feed, while in others it is said to live on plant-juices. The palpi of mosquitoes are very long in most species.

The **eggs** (Plate 41, Fig. 7) of the mosquito are laid in little clusters on the surface of the water

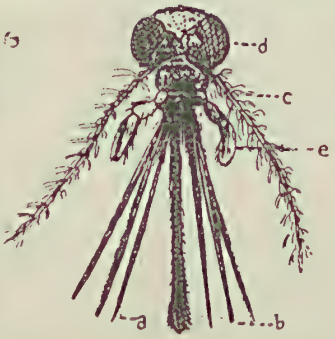


Fig 1 Piercing mouth of Female
a. Sheath b. Stylets
c. Antenna d Eye
e Palp.

Fig 2. Larva
a Breathing Tube

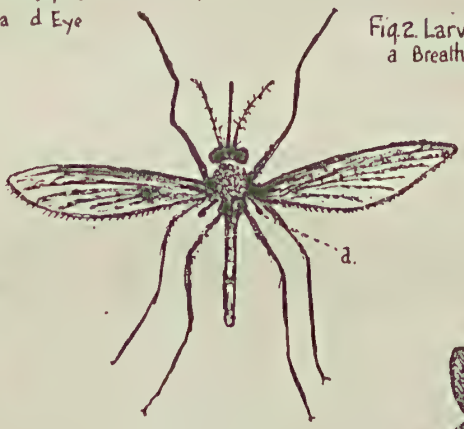


Fig 3 Adult (female)
(a Haltere)

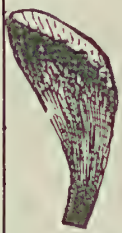


Fig 4 Breathing Tube
of Pupa

Fig 5 End of Breathing Tube of
Larva

Fig 6 Pupa
a. Breathing Tube

Fig 7 Egg Cluster

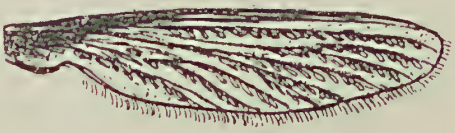


Fig 8 Wing with Scales

MOSQUITOES.

by the mother-mosquito. They are sticky at first, and so cling together, but in regular order; and as they dry they form a solid mass of eggs—a little raft which is beautifully balanced and floats on the surface of the water. The lower ends of the eggs are wider and thicker, and so the "raft" is heavier at the base. When water falls on it it just tosses and rights itself quickly. From the lower end of each egg a tiny **larva** (Plate 41, Fig 2), called a "wriggler" by children, emerges and wriggles away—it looks like a very small piece of wriggling thread, for the larva is elongate, with a distinct head and thorax. The thorax is much wider than the abdomen. There are three tufts of long hairs on each side of the thorax, and a tuft on each side of each of the abdominal segments. At the end of the abdomen are two organs; one is the **breathing tube** (Plate 41, Figs. 2 a and 5)—a long cylindrical tube with four flaps at the free end. These flaps close over when the "wriggler" goes below the water. The larva swims about with its head down and the tip of the abdomen up. Thus the breathing tube is brought on a level with the water, receives the air, and then the curious "wriggler" lowers itself again. We see that the mosquito larvæ have no gills like fishes or dragon-fly nymphs, but have to rise to the surface of the water to get their air-supply. The other organ at the end of the abdomen is the excretionary tube, rather funnel-shaped, with tufts of hair.

The **head** of the larva is surrounded by tufts of hairs and two appendages like arms, with hairs on

them. These are in constant motion, and promote a current of water, which is sent along to the mouth of the mosquito "wriggler," carrying tiny animals and scraps of vegetable food. One can see them moving along on their heads, feeding on the tiny vegetable growths which flourish on the leaves of the long, grass-like *Vallisneria* and other water plants in the fish bowls, or burrowing their heads into the sediment at the bottom of the bowl. The heavier head and thorax form a good balance or anchor, as the larva is feeding head downwards. It moults six times, increasing in size after each moult. It then pupates.

The **pupa** (Plate 41, Fig. 6) is a curious little object like a little "water gnome," with its great "head" (which is really the head and thorax) and its large, ear-like breathing tubes slit down part of one side and resembling "donkey's ears." These are situated on the head of the active little pupa instead of the tail (as was the case in the larva). (Plate 41, Fig. 6 a and Fig. 4). Unlike most pupæ, it is very active; but it cannot eat, because the mouth parts and all its body is covered by the pupal shell. (Note that the pupa is naked or free, and not enclosed in a puparium.) As before mentioned, it breathes by means of a pair of tubes on its head, and it has to come to the surface of the water to get an air-supply. It moves about with its head upwards, and by curling its body round it gives a series of jerks, sends itself through the water, and is called a "tumbler." The abdomen of the pupa tapers to the end, and terminates in

two broad flaps or tails, with tufts of hairs present also.

When the adult is about to emerge, the pupa becomes inert, rises to the surface, and does not rush away when touched, as the younger pupæ do. The body straightens somewhat, and at last there is a splitting of the pupal shell along the back. The head and thorax emerge, and then the insect has a rest. In a little while it draws itself out of the case, resting its legs on the surface of the water. Its body is more or less vertical while this is going on, and acts as a "mast" to the little boat-like pupal shell. It at last rests on the surface of the water, "as lightly as a fairy," and may wait there till its wings dry, or it may walk with dainty footsteps to the reeds, etc., where it rests in more safety till its wings dry, which they do very rapidly.

The larvæ of mosquitoes can adapt themselves to many conditions of life. We have found them in stagnant water, in damp mud at the bottom of a porcelain bowl left in the open—they lived here for months in a thin layer of damp mud. We also got them in rock pools of the harbour, where the water rose in high tide, *ex.*: Woollahra Point and at Maroubra, and other places on the coast. We took some of these larvæ and placed them in fresh water, and they did not seem to be the least put out at the change. The larvæ of these mosquitoes were larger and stouter-looking than those of the common mosquito, *Culex albo-annulatus*. These salt-water-loving mosquitoes were identified as *Culex vigilax*.

We did some very interesting work in recording the moults of the mosquitoes. We took six tiny larvæ just after they emerged from the egg, and placed each one separately in a small bottle, there being six bottles, and noted the casting of the skins of each larva, making a record of the dates.

FAMILY CHIRONOMIDÆ.

(Gnats and Midges.)

These insects are very similar to the Mosquito family, but are smaller and in some cases are minute. The wings have not scales present as those of mosquitoes have, but they are often clothed with scattered hairs, with a deep fringe of hairs on the outer rim.

The larvæ vary in habits, some being water lovers, while others are terrestrial. There is a curious little larva of one of the midges (*Chironomus*), which is like a little brilliant red worm which is elongated and narrow in form. These worm-like larvæ burrow in the mud of ponds. We bred out these midges where larvæ were in water in a vessel left exposed to the rain, and with an accumulation of decaying leaves. We put some of the mud and water weeds into a glass jar, and the larvæ were quite happy. The antennæ of the male have a rod-like axis, tapering towards the apex and thickly clothed with long hairs, forming fine plumes. The antennæ of the female are made of several distinct joints, with only a few hairs present on each segment.

Another species of Chironomid is the sand fly (*Ceratopogon molestes*), which is such a pest on beaches and at places such as National Park. We know it well by the irritation caused by its bite, but it is small, and few are very familiar with the actual fly. The larvæ live in damp places, or in water.

FAMILY TIPULIDÆ.

(Daddy-long-legs, Crane Flies.)

(Plate 42.)

These are often mistaken for large, clumsy mosquitoes with very long slender legs. Their flight is slow, and they bump into rocks, shrubs, etc., often losing a leg by these encounters, but continuing their way seemingly without concern. We knew children who used to sing:—

"Silly Daddy-long-legs
Clumsy and slow,
Bump a rock and lose a leg,
But what is that to you?"

And someone has written:—

"My six long legs, all here and there,
Oppress my bosom with despair."

Characteristics: The proboscis is short and stout, and there are usually but two slender stylets. The antennæ are very long and thread-like in the female, but those of the male are much shorter and very handsomely plumed. The halteres or balancers are naked and with an elongate stalk (Plate 42, Fig. 2 a). There is a marked V-shaped suture on the back of the thorax. The female has horny-pointed valves at the end of the abdomen with which she cuts through the soil to deposit eggs in the ground. Many larvæ live in the ground; they are elongate and like short worms. In America and Europe

Fig 1. Larva of Tipulid fly

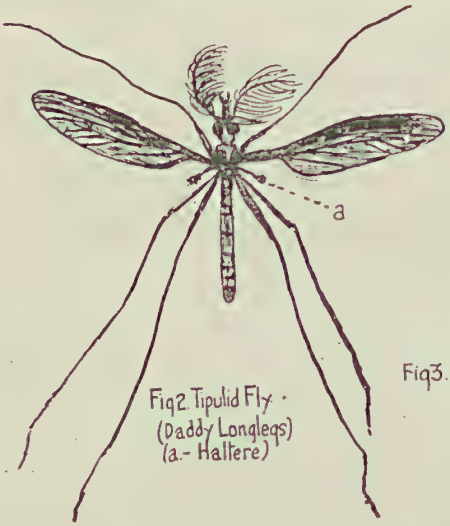


Fig 2. Tipulid Fly · (Daddy Longlegs) (a.- Haltere)

Fig 3. Pupa. of Tipulid

Fig 4. Bombylid or bee fly.

Fig 5. Robber or Asilid fly.

Fig 6. Pupal shell of Bombylid fly (Front view) a. File.

Fig 7. Back view of same. a. File.

Fig 8. Haltere of Tipulid

they feed on the roots of cereals and young plants, just below the surface of the ground, hence may become pests. Others are found in the soft decaying wood of tree stumps, or in damp soil.

The **pupa** (Plate 42, Fig. 3) is not enclosed in a puparium, but is free. On the body of the pupa there are rows of bristles which enable it to work its way out of the soil, when about to change to the adult winged form. It emerges by means of a T slit. We have noticed the tipulids or "daddy-long-legs" flies resting in enormous numbers on the shrubby she-oaks near the edge of the water at Tuggerah, Port Hacking, etc. We collected the "giant" tipulid in moist caves on the Blue Mountains. They are very numerous in nearly all parts of the bush.

Reaumur thus describes their flight over grass lands: "Although they sometimes fly a considerable distance when the sun is bright and hot, they generally do not go far; often, indeed, only along the ground, or rather along the top of the grass. Sometimes they only use their wings to keep them above the level of the herbage, and to take them along. Their legs, particularly the hind ones, are disproportionately large. They are three times the length of the body, and are to these insects what the stilts are to the peasants of marshy and inundated countries, enabling them to pass with ease over the higher blades of grass."

Comstock suggests that as the abdomen and the ovipositor are both unusually long, the long legs enable the insect to use the ovipositor more firmly. "When about to lay her eggs the female stands nearly

upright, and, bringing the abdomen at right angles to the surface of the earth, thrusts the ovipositor into the ground. After placing one or two eggs in the hole thus made, she moves forward a few steps and repeats the operation."

FAMILY STRATIOMYIIDÆ.

(Soldier Flies.)

Some of these are brightly marked, hence the name of "soldier fly." The body is broad and flattened. The antennæ vary; some are elongate, others are short and broad at the base, with a bristle at the apex.

The **larvæ** vary in habits, some living in water, some in damp soil, and some in decaying wood. Some are vegetable feeders, feeding on decaying vegetable matter; others are carnivorous.

The **pupa** is formed within the last larval skin or puparium, but the latter does not form a seed-like structure, but retains the ringed appearance of the larva (Plate 40, Fig. 8)

FAMILY TABANIDÆ.

(March Flies.)

These flies have a fleshy proboscis and pointed stylets. They are blood-sucking insects. The head is well separated from the thorax and truncate (cut off abruptly) at the back: this is characteristic. The abdomen is usually broad and flat. The antennæ vary, but do not have a terminal bristle.

Life history. The eggs are laid by the mother tabanid in water or on reeds or stones near the water. They are usually in clusters of hundreds, and the young fall into the water and feed on small water creatures. Others lay eggs on damp soil or in marshy places, and these **larvæ** may have spine-like processes on the under-side of the body, by means of which they can push themselves through the mud, etc.

The **pupa** is free, having no puparium or larval skin enclosing it. The adult escapes by a T-shaped slit.

These march or marsh-flies are very troublesome in summer, particularly on the mountains and in the country. They fly quietly and rather slowly when approaching one, and they are most persistent in their attempts to alight. We caught seventeen in one hour by just sitting still under a tree in an orchard on the mountains during mid-summer and awaiting their attacks. Their bite is very irritating,

and said by some people to cause blood-poisoning. They torment cattle by biting them about the eyes, and it is thought that they spread anthrax among them.

We noted for several years at Clarence Siding, Blue Mountains, that in December and January there was a large species which was a plague to us in our walks in the bush. In April we found few of the larger species, but there was an abundance of a small type only half an inch in length. As we sat reading, it was necessary to catch them with a net or beat them with a short branch. Dozens were caught in one hour, for, being very slow of flight and most persistent in their attention to us, it was easy to capture them.

FAMILY BOMBYLIDÆ.

(Bee Flies.)

(Plate 42, Figs. 4, 6 and 7.)

These flies resemble bees, both in appearance and habits. They are usually very hairy, and their wings are often mottled with smoky patches. They usually have rather a long proboscis, which is used to send down to the nectar of flowers on which the flies live. They fly very quickly for long distances, and some of them move their wings so rapidly that they seem to be quite still over the flower; they dart away with a quick, jerky movement. We have observed these flies on flowers of *Leptospermum*, *Angophora*, and *Eucalyptus*. This was the large mottled wing type.

Comstock says: "The larvæ are parasitic, infesting lepidopterous larvæ and pupæ and the egg sacs of Orthoptera."

Froggatt records: "The life history of our species is little known, but I have bred several out of the clay nests of wasps, and two out of lepidopterous pupæ (*Agrostis*).

David Sharp describes how Fabre discovered the habits of a bombylid fly (*Argyromoeba*) which laid its eggs on the mud cells of a mason wasp. The tiny maggot, after waiting some days, makes its way into the cell by way of tiny cracks. Sharp thus

describes it: "It entered this cell as a tiny slender worm through a minute orifice or crack, but it is now much increased in size, and exit for a creature of its organisation is not possible. For some months it remains a quiescent larva in the cell of the bee, but in spring of the succeeding year it undergoes another metamorphosis and appears as a pupa provided with a formidable apparatus for breaking down the masonry by which it is imprisoned. The head is large, and is covered in front with six hard spines, to be used in striking and piercing the masonry." When the hole is made in the mud cell the adult escapes from the puparium. The larva or maggot feeds on the larva of the mason bee by sucking the juices of the bee-magot.

Certain bombylid flies parasitise the egg masses of locusts.

We bred out a small bombylid fly (Plate 42, Fig. 4) from the mud cells of an eumenid wasp. The pupal shell was found outside the mud cell and we give a sketch of same (Plate 42, Figs. 6 and 7), for it has these six hard spines for escaping from the mud cell. The adult fly was a beautiful little insect with smoky wings.

Fig 1 Surphid fly (one wing removed)

Fig 2 Cocoon

Fig 3. Larva

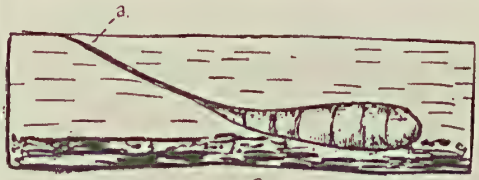


Fig 4 Rat-tailed Larva of a Surphid fly
a - Air tube

Fig 5. Antenna
a Bristle

Life History of Surphid or Hover Fly

Fig 6. Types of Antennae of Calyptrate Flies
a Tachinid b. Sarcophid. c. Muscid

FAMILY SYRPHIDÆ.

(Hover Flies.)

Many of these flies are brightly coloured, some seem to mimic wasp or bees. The syrphid flies poise seemingly motionless over flowers, hence are termed "hover flies." This motionless appearance is due to the rapidity of the vibrations of the wings. They are seen hovering over flowers or leaves, either sipping the nectar of flowers, or the mother-insect is laying eggs on plants where aphides are present.

The **larva** (Plate 43, Fig. 3) is a long grub without legs, but there are lateral projections of the body which enable it to hold on or move forward, and usually there is a strong anal segment by means of which it clings to the leaf. The "mouth" is in the form of a proboscis, very elongate, which can be pushed out and then withdrawn. We watched the syrphid larvæ feeding on aphides on the wild cotton plant (*Gomphocarpus*). The larva or grub looked like an elephant in the way it thrust out its long trunk and "spiked" an aphis.

The **pupa** (Plate 43, Fig. 2) is not free, but is enclosed in a larval skin or puparium, which in most cases is intermediate between the seed-like puparium of the house fly and that of the soldier fly, whose puparium retains its larval form. The syrphid puparium is broad at the apex and tapers toward the point of attachment. With a lens one can see the spine-like tubercles which had been present in the larva, and though the pupa is somewhat seed-like in appearance it is not smooth and rounded like that of the muscid flies (house flies, blow flies).

The **pupa** drops to the ground after remaining for some time on the plant. This is the life history of the common hover flies such as *Syrphus viridiceps* and *Syrphus pucillus*, whose larvæ are found on garden plants, wheat, etc.

But some species of syrphid flies have larvæ with elongate tubular processes at the end of the body, which can be extended to two or three inches, and contracted again. By this means they get a supply of air, which enables them to live in muddy water and in fluids caused by decomposition of animal or vegetable matter. There is a curious introduced syrphid fly called the "drone fly" or "bee fly." It is more like a bee in general appearance, and its larva has the "rat-tailed" body described above (Plate 43, Fig. 4 a). Its name is *Eristalis tenax*.

FAMILY ASILIDÆ.

(Robber Flies.) (Plate 42, Fig. 5.)

These are very common in Australia, and range from small insects, about three-quarters of an inch, to the large-bodied robber fly (*Craspedia coriaria*), which is one and a half inches long. The legs are strong and covered with stiff hairs. These are insects with swift, strong flight. The head is clearly cut off from the body and is very mobile. There are no squamæ present. They have excellent vision, to enable them to sight a probable victim. The antenna consists of four joints; the fourth joint is bristle-like but fairly thick and terminal, thus differing from some of the other groups. (Plate 40, Fig. 7 b.) The proboscis is fairly long and stout, for these flies are predaceous. Sharp thus describes them: "These flies are most voracious, their prey being insects, which they seize alive and impale with the rostrum (proboscis). They are amongst the most formidable of foes, and fear nothing, wasps or other stinging insects being attacked and mastered by the stronger species without difficulty. They have been observed to capture even dragon flies and tiger beetles. As is the case with so many other insects that prey on living insects, the appetite in the Asilidæ seems to be insatiable; a single individual has been observed to kill eight moths in 20 minutes."

In many Asilids the abdomen tapers to a point. Little is known of the life history of the larvæ. Some species are said to be predaceous on other insects and live in the ground.

GROUP CALYPTRATE MUSCIDÆ.

The insects in this group are distinguished from another group, the **Acalyptrate muscidæ** (fruit flies), by the presence of well-developed squamæ (see Note 3 b, below) and by the venation of the wings.

In the calyptrate muscidæ are several families. The general characteristics are as follows:—(1) The **larvæ** are without a differentiated head; the jaws are the most prominent feature of the anterior end. (2) The **pupæ** are always enclosed in a hardened, seed-like **puparium**—that is, the last larval skin, which acts as a "cocoon." (Plate 44, Fig. 3.) (3) The **adult** (a) emerges from the puparium by pushing off a circular lid; (b) there is a small wing-like structure at the base of the wings called a **squama**—these squamæ cover, or partially cover, the halteres or balancers; (c) the males have eyes which meet across the head and form the greater part of it.

A. **Family Tachinidæ.** The bristles of the antenna are quite bare. (Plate 43, Fig. 6 a.) *ex.*: *Tachina*, which is parasitic on caterpillars.

B. **Family Sarcophagidæ**, or "flesh flies." The bristle of the antenna is feathered, but only at the base: (Plate 43, Fig. 6 b.) *ex.*: *Sarcophaga*, parasitic on locusts (short-horned grasshoppers).

C. **Family Dexiidæ** ("metallic green flies"). The

Fig1 Larva.

Fig2. Adult.

Fig3 Puparium.

Fig5. Wing of Acalyptrate flies "cell a" open.

Fig4. Posterior End of Maggot
a. Spiracles.

Fig6 Wing of Calyptrate flies "cell a" closed.

Fig.7. Larva of Hairy-maggot blow fly

Fig8. Puparium of same

BLOW FLY.

bristle of the antenna is feathered to the tip (Plate 43, Fig. 6 c); the abdomen has bristles strongly developed on the dorsal side.

D. **Family Muscidæ.** The bristle of the antenna is feathered to the tip; the abdomen is without bristles except at the tip. *Ex.*: house flies, blow flies, etc.

E. **Family Anthomyidæ** differs from the other calyptrate families in that the cell of the wing marked "a" is open (Plate 44, Fig. 5 a), whereas in the other calyptrate muscids it is closed (see Plate 44, Fig. 6 a). *Ex.*: the common beach fly.

FAMILY TACHINIDÆ.

These flies parasitise caterpillars, the larvæ of saw flies, and young grasshoppers. They are similar to, but can be distinguished from house flies by the bare bristle of the antennæ, for it is feathered in the house fly.

We kept a very large caterpillar of the case moth (*Metura elongata*) in a cardboard box with a glass front, putting in a dish with moist sand and a sprig of the cypress-tree on which it was feeding; the latter was placed in the moist sand. For two months the caterpillar lived on, walking round the box, and seemingly quite content. One morning we observed dozens of queer-looking creatures scattered over the glass-front of the box. They were tachinid flies which had just emerged, and their wings were not yet expanded and dried; hence their curious appearance. At last their wings were spread and nearly dry, when we placed them in a net and then into the killing bottle to count them. A few escaped, but we counted 127 flies, all of which were bred out of the one unfortunate caterpillar. The mother tachinid lay her eggs on the caterpillar; they are very tiny, and they are made secure by a sticky fluid which then dries and fixes the eggs firmly on to the host. The maggots then make their way into the caterpillar and feed on its tissues. The full-grown maggots then emerge

from between the segments of the caterpillar and pupate in the case beside the remains of their victim. We opened the case of our caterpillar, and counted 143 cocoons left by the flies. They were a reddish brown, consisting of the seed-like puparium or last larval skin.

These flies have large squamæ which completely cover the halteres, and the cell of the wing, marked "Cell a," is either completely closed or almost closed (Plate 44, Fig. 6.) Sharp records that a certain species of tachinid fly parasitises the silkworms, the egg being laid on the mulberry leaves, and is then taken into the body of the silkworm with its food. Others are said to lay eggs on the food supply of Bembex wasps.

FAMILY SARCOPHAGIDÆ.

(Flesh Flies.)

The habits of these flies are thus described by Froggatt: "They lay their eggs on living larvæ, upon meat or other exposed food, and are known as 'scavenger flies' because they frequent evil-smelling places like pig-sties and slaughter-yards. Some species are known to deposit their larvæ in the nostrils of sheep, and there are several records of death of human beings from infestation by these maggots." It is recorded, however, that they parasitise the young of the plague locust (a short-horned grasshopper), and this is of economic importance.

Note that the antenna of the sarcophagids has the bristle plumed only at the base. (Plate 43, Fig. 6 b.)

The common *Sarcophaga* is a little larger than a house fly, and has a marked grey and black appearance, with black bars on the thorax and with a pattern more or less regular on the abdomen.

FAMILY DEXIIDÆ.

(Metallic Green Flies, Nimble Flies.)

The bristle of the antennæ of these flies is plumed right to the tip, and this is the main distinction from some of the other families of this group. Bristles are present on the dorsal side of the body, and this and their larger size serve to distinguish them from house flies (in the next family). Some of these flies are very handsome. The legs are strong and the eyes large. They parasitise the larvæ of lamellicorn beetles. The larvæ pupate in the seed-like puparium or cocoon. *Rutilia* is one of the commonest of these flies. We have captured *Rutilia* on some of the honey-bearing bush flowers, such as tea tree.

FAMILY MUSCIDÆ.

(House Flies, Blow Flies.)

We will give an outline of the life history of the house fly, which will serve as a type for the group (Plate 40, Figs. 1, 6).

The common house fly, *Musca domestica*, lays her eggs in decaying vegetable matter, and in manure, more especially horse-manure. It is this fact which renders them so numerous along country roads and in paddocks. Making proper manure heaps and covering it with soil or sprinkling with lime is often resorted to in order to prevent the breeding of flies in garden manure heaps. Each female lays about 100 eggs, and they hatch out in six or seven hours. The maggots feed on the decaying vegetable matter, and are ready to pupate in five or six days. They are adult in five days after pupating. The total length of time from the egg to the emergence of the adult is about two weeks. In summer there are about one dozen generations in the one season.

The **maggot** or **larva** is soft and of a creamy colour; it is narrow at the head and thick and blunt at the end. (Plate 40, Fig. 2.) The head is small, characterised by a pair of dark jaws. Near the mouth are a series of minute pores; these are openings of the tracheal tubes. At the posterior or thick end of the maggot there is a plate, on

which the two spiracles open. When these anterior and posterior spiracles are present there are no spiracles along the sides of the body, as we saw in the caterpillar and grub. The larva, after a series of moults, is ready to pupate; it retires within its last larval skin, which shrinks and hardens and becomes a seed-like puparium within which the pupa is formed. (Plate 40, Fig. 3.) When the adult emerges it pushes off the end of the puparium, which is a little lid or cap, and makes its way out of its prison. Adults may winter over to be ready to lay eggs in the next spring.

The Proboscis.—The house fly can neither bite nor sting, for it does not possess the stylets, as the majority of dipterous insects do. The mouth is modified to form a fleshy proboscis, with muscular expansions at the free end to form a kind of broad sucking lip. (Plate 40, Fig. 4.) On the surface of this lip are a series of parallel grooves, along which the liquid food is drawn. But the house fly is not only able to devour liquid food. We have seen one standing on a sugar lump, and it seemed to be playing with some of the grains with its proboscis and front legs; it was really preparing it. The mouth of the fly is surrounded by 50 or 60 rods, or teeth, which are used for grinding hard surfaces to reduce them to powder and so allow the saliva from the fly's mouth to reduce them to a sweet, sugary fluid which can be absorbed by the fly. It is omnivorous, however, eating almost anything which can be reduced to a liquid—sweet or evil smelling and tasting.

House flies are pests, for they alight on decaying animal and vegetable matter, on filth laden with germs. These germs are transferred to the hairs on the feet and body of the fly and then transmitted to the exposed food in houses. Thus disease may be spread. Hence the importance of burning or covering up all waste organic matter.

If one catches a fly and places a leg under the microscope, one can see why the fly is so capable of carrying disease germs. The legs are clothed with numerous hairs; its feet also are rich in hairs, and have two curved claws on the last tarsal joint of each foot. Beneath the claws is a pad, which is a hollow sac secreting a sticky fluid. On the lower surface of the pad there are a number of hollow hairs, through which the sticky solution secreted by the pad issues in sufficient quantities to allow the fly's feet to adhere to a smooth surface without actually sticking. This is why flies can walk on the ceiling and up smooth panes of glass. The claws are used when a fly is walking over a rough surface.

We might remind our junior readers that a fly is a "grown-up" insect no matter how tiny it may be. The fly-babies are the maggots. Should there be tiny flies it means that it is a different species; or in some cases it may be a poorly-fed specimen—the maggot or larval stage being without the proper food-supply.

Life History of the Blow Fly.

(Plate 44.)

The eggs are laid on animal or vegetable matter. Blow flies are pests in the house, laying eggs on food. We know how we have to guard meat in the summer-time, especially on the Mountains or in the country; indeed, in the city, too, it is often difficult to keep meat from the ravages of these flies. The eggs are laid on meat, etc.; or, in very hot weather, tiny maggots may be deposited. We have observed a blow fly deposit young maggots, about an eighth of an inch in length, on meat.

The **maggot** or **larva** (Plate 44, Fig. 1) is smooth and of a creamy colour. It can "hop" by curving the body and then straightening it quickly. Maggots move about freely in semi-fluid decaying matter. The head is very small, and cannot be clearly defined from the thorax, the most noticeable feature being a strong, dark pair of chitinous jaws. The head can be withdrawn and hidden by the thoracic segments.

The maggots moult and at last pupate in the ground, or they may pupate in the medium (if solid) in which they are feeding, the last larval skin being changed into the seed-like puparium. When the adult fly escapes one can see the little round lid it pushed off from the end of the puparium.

The mouth, like that of the house fly, is fitted for sucking only. The end of the proboscis is produced into a broad, lip-like organ with a series of grooves, through which the moisture runs when

being sucked up. (Plate 40, Fig. 4.) There are a series of teeth-like spines present in the mouth cavity, by means of which the food can be scraped and torn and reduced to pulp, aided by the saliva of the mouth.

There are two common blow flies—the brown one (*Calliphora villosa*) and the blue blow fly (*Calliphora oceaniae*). Mr. Froggatt records that these flies attack the soiled wool of sheep, laying eggs in it, and afterwards the maggots attack the flesh of the sheep. He also records *Calliphora rufifacies*, or the "sheep maggot fly," or "hairy maggot," or "metallic blue blow fly," which is becoming the worst pest to sheep out West.

The maggot of this species is not smooth, and the pupa retains the tubercles or fleshy spines in the puparium. (Plate 44, Figs. 7 and 8.)

Lucilia, or the "green bottle fly," is the sheep maggot fly of Great Britain, and it is recorded as attacking sheep in Australia. *Lucilia* visits many flowers, such as parsley and fennel, of the family *Umbelliferae*. It feeds on a secretion on the top of the ovary, and in so doing it may cross-pollinate the flowers.

Another genus is *Stomoxys calcitrans*, which is not unlike the house fly, but it has a piercing and sucking mouth instead of the purely sucking mouth of the house fly. It lays its eggs in stable manure, etc. It is a blood-sucking fly, and may spread disease, such as typhoid, by alighting on food.

The tsetse fly of South Africa (*Glossinia morsitans*) is a very serious pest. It attacks cattle,

causing disease; it also bites man, but does not transfer this cattle disease to man.

Glossinia palpalis causes the "sleeping sickness" in Africa. The larvæ of *Glossinia* are developed in the body of the female, and are laid when nearly full grown; hence, when hatched, they pupate almost at once.

Family Anthomyidæ: these are very similar to house flies. We often capture this fly on the beaches. It is an intermediate group between the calyptrate muscids (squama covers the haltere) and the acalyptrate muscids (a squama does not cover or only partly covers the haltere). It is near to the latter group because it has the "cell a" (Plate 44, Fig. 5) usually open, while it is classified with the calyptrate muscids because it has squamæ covering the halteres.

The antennæ have the typical "bristle," which may be bare or clothed with plumes to the top.

These flies are fond of visiting flowers, such as those of the family Umbelliferæ (parsley, fennel) and Compositæ (cosmos); we have captured them on fennel whose flowers were swarming with these flies; they were feeding on the nectar.

The larvæ vary in habit; some feed on decaying vegetable matter, some are parasitic on other insects, and some are pests on living plants. The larva of one species attacks the roots of cabbage and cauliflowers (family Cruciferæ), and another species attacks the bulbs of onions. These flies are recorded as pests in America.

Family Œstridæ: In this family we have "bot flies," "sheep bots or sheep nostril flies" and "warble flies." Of warble flies Froggatt records: "The members of the genus *Hypoderma* are a very serious pest in Europe or other countries where they infest cattle, and are known as 'warble' or 'bot flies.' The fly lays her eggs upon the back of the beast; the tiny larva makes its way through the hide, beneath which it lives and feeds upon the putrid matter caused by the irritation of its presence: it finally produces an inflamed blister-like swelling or 'warble,' eventually working its way out through the hide and falling to the ground where it buries itself in the ground." It is not found in Australia.

In this family are some very serious pests. The bot fly (*Gastrophilus*) (Plate 45) attacks horses. The mother fly lays her eggs on the head, shoulders, and front legs of the horse. They adhere firmly to the hairs, for they are fastened by a sticky secretion. They are licked off by the horse, and the saliva loosens the eggs from the hairs. The maggots hatch out in the horse's mouth, and are carried down to the stomach. The maggot is not smooth like most maggots, but has a serrated "frill" on the edge of each exposed segment. (Plate 45, Fig. 1.) It also has a strong pair of jaws, by means of which it clings to the tissue of the horse's stomach, where it absorbs its liquid food and develops. (Plate 45, Fig. 3.) These maggots are called **bots.** At last the bot is "grown up," and loosens its hold and is carried out of the horse's body in the excrement. It pupates in the soil.

Fig 1. Bot or Larva

Fig 2. Group of Bots in Stomach of horse

Fig 3 Jaws of Bot

Fig 4 Adult Female

Fig 5 Eggs of Bot-fly on hair of horse

BOT FLY.

The large dragon fly or "horse-stinger" is sometimes seen chasing bot and other flies, and this harmless insect has been accused of attacking horses. The mistake probably came about in this way: The horses seem to dislike the very hum of the bot fly, and dart away when they hear it. Now, the bot flies are chased by dragon flies, but, as the latter are so much larger, those near the horses saw only the larger insect—saw also the horse rearing or turning away, and imagined it was the dragon fly which was attacking, instead of which it was the hum of the bot fly which disturbed the horse.

Another species is *Oestrus ovis*. This fly deposits maggots in the nostril of the sheep, and they make their way up in the space behind the nose, and here they feed till they mature, when they are expelled by the sneezing of the animal. They pupate in the earth. We have seen sheep bots taken from the brain of a sheep which had been killed by these bots which had found their way from the nostril to the brain of the sheep.

ACALYPTRATE MUSCIDÆ.

This group includes a number of flies which are closely allied to the calyptrate muscidæ. The acalyptrates differ in the venation of the wing. The cell marked "a" is open. (See Plate 44, Fig. 5.) The squamæ are either absent or rudimentary.

FAMILY TRYPETIDÆ.

(True Fruit Flies.) (Plate 46.)

To this family belong some very serious pests.

Life History of the Common or Mediterranean Fruit Fly.

(*Ceratitis capitata.*)

This is a mottled fly which is a little smaller than the house fly. The mother fruit fly lays her eggs in such fruits as peaches, apricots, pears, apples, oranges, etc., and the fruits become pulpy and soft and are ruined. The little fly-maggots feed on the fruit juices, and, when mature, make their way out of the fruit to the ground, where they pupate Mr. W. B. Gurney, in his work on "Fruit Flies," gives this account of the larva of this fly:—"The maggot has the pointed head and blunt posterior end so characteristic of many fly grubs. (Plate 46, Fig.2.) The narrow end bears a pair of black, curved jaws capable of being drawn into and protruded from the head, and which are used for tearing the fruit tissue. They frequently skip or jump, in the manner so often noticed, when taken from the fruit. The maggot doubles the body, hooks the jaws to certain small lobes about the anus, sets up a strong muscular strain, and suddenly releases the jaws from their hold, the effect of which is to jerk the body some six or eight inches away. These movements

are repeated until apparently the maggot finds itself in a more congenial position as to food or moisture, or out of the light, or where it can burrow into the soil to pupate. On each side of the head is a cluster of minute spiracles or breathing pores arranged in a row. (Plate 46, Fig. 4.) A pair of tubes or tracheæ running through the body connect these anterior spiracles with two sets of spiracles at the posterior end, which are arranged in two sets of three openings. (Plate 46, Figs. 2 and 3.) Each of these posterior openings is guarded by a row of fine, closely-arranged hairs, which are probably used as screens against the entrance of juice and dirt into the tracheæ or breathing tubes."

The **pupa** is within the seed-like "puparium." (Plate 46, Fig. 7.) Mr. Gurney records that the maggots which are found in quinces and apples often pupate in the fruit: "These fruits, being less juicy than citrus fruit, are therefore not likely to drown or cause the pupæ to decay, as would the citrus fruit."

Another fruit fly is a native of Australia, and is called the Queensland fruit fly (*Dacus tryoni*). Mr. W. B. Gurney makes this record:—"The New South Wales variety of the above species attacks **Orchard fruits**—oranges, mandarins, comquats, peaches, and nectarines, and occasionally plums, apples, pears, lemons, and loquats. **Wild fruits**—white ash berries (*Schizomeria ovata*), cheesewood berries (*Acronychia laevis*), black apple or native plum (*Sideroxylon australe*), wild black fig (*Ficus stephanocarpa*), and rarely lillipilly (*Eugenia*

Fig 1. Egg

Fig 2. Larva
a Air Tube

Fig 3. Posterior Spiracles of Maggot

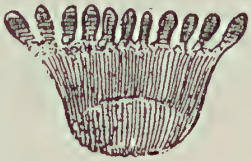


Fig 4. Anterior Spiracles of Maggot.

Fig 6. Spathulate process of Male.

Fig 5. Fruit Fly

Fig 7. Puparium

Fig 8 Adult.
Emerging.

FRUIT FLY.

Smithii). The eggs hatch in a few days. The maggot stage appears to occupy two or three weeks. The pupal stage in summer occupies 14 to 20 days. The adult may live several weeks. Thus from the laying of the egg to the adult stage occupies about five or six weeks in summer, and, the flies living a week or two as adults, the total life may be two months or more. There may therefore be several generations in the summer. Cold, as was found in the case of the Mediterranean fly, retards development."

There is yet another fruit fly to consider—the Island fruit fly (*Trypeta musae*). The life history is similar to that of the types described before, but the development is slower. Mr. Gurney says, as regards damage caused by maggots: "Although occasionally marketable fruits are affected, they chiefly infest already damaged or unmarketable fruit; and it is to be noted this fly is not to be dreaded like the Mediterranean and Queensland flies, which habitually puncture and deposit their eggs in sound fruit."

ORDER DIPTERA.

Sub-order: Aphaniptera or Siphonaptera.

(Fleas.) (Plate 47.)

Fleas are regarded by some authors as degenerated dipterous insects, and are usually placed in a special sub-order.

Characteristics.—They are wingless insects which have two pairs of tiny flaps—one pair on the mesothorax, and another pair on the metathorax, just in the position where the wings are usually placed in insects. These flaps are probably rudimentary wings.

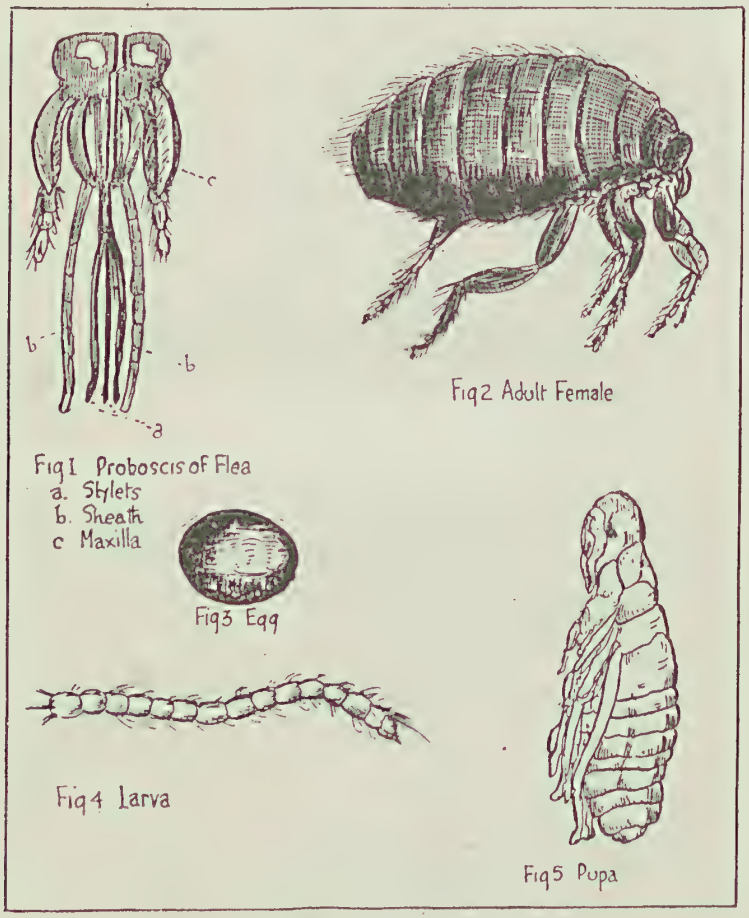
Fleas are compressed vertically, and not laterally (as is more usual with insects—for example, bugs and cockroaches). This compression enables them to get into crevices and cracks and hide in blankets, and also to move easily in the fur of cats and hair of dogs. The integument is segmented and tough; it is of a bright, reddish brown colour and is polished-looking. It is the breaking of this tough skin which makes the "crack!" in killing a flea.

The head and thorax are not clearly marked off from the body. The head is small. The eyes are simple, not having the numerous facets of compound eyes. Some fleas are said to be blind.

The mouth (Plate 47, Fig. 1) is curious; it is wonderfully fitted for its blood-sucking habits. The mandibles or biting jaws are here, in the form

of long, linear stylets with minute serrations; there is a single piercing stylet present also. These three narrow linear processes (Plate 47, Fig. 1 a) are

PLATE 47.



THE FLEA.

enclosed by a pair of long, jointed labial palps, which form a sheath protecting them. (Fig. 1 b.) The maxillæ or outer jaws are present, with palps. (Fig. 1 c.)

The flea has six legs. The first pair appears to be joined to the head, but is fastened to the prothorax. The hind legs are very large and strong, and enable the flea to hop so well. All the legs are furnished with hairs.

The **eggs** (Plate 47, Fig. 3) are laid in dirt in houses, buildings, and also in the fur of animals such as cats, rabbits and dogs. They are laid loosely in the fur, and may drop to the ground as the animal walks. Of course, they are very tiny.

The **larva** (Plate 47, Fig. 4) is worm-like. Sharp describes the larva, when just hatched, as having on its head a curious structure for breaking open the egg shell. It has a biting mouth and 10 pairs of spiracles, for breathing, along the side of the body. It lives in refuse and dirt. The **pupa** (Plate 47, Fig. 5) is enclosed within a tiny cocoon.

The **adult** emerges within a fortnight.

The house flea is *Pulex irritans*; the bird flea is *Pulex avium*; *Pulex serraticeps* of dogs and cats—but fleas seem to pass freely from one animal to another.

The fleas on rats may carry germs of disease. In Sydney it was proved that rats carried the germs of plague, and, with the temporary extermination of rats, the plague subsided.

The Chigger or sand flea of tropical America is a pest which buries its body in the flesh of man, causing irritation and disease.

ORDER HEMIPTERA.

(Cicadas, Froghoppers, Bugs, Scale Insects, Aphides, etc.)

The name "hemiptera" is given from the fact that some families have the fore wings divided into two zones—(a) an upper horny, opaque part, (b) a lower membranous and semi-transparent portion. (Plate 52, Fig. 10.) The sub-order **Heteroptera** (varied wings) includes insects with such wings.

A more distinct and common feature lies in the **mouth** parts (Plate 48, Figs. 6 and 7), which are in the form of a jointed sheath enclosing four stylets or hair-like bristles. It is a piercing and sucking mouth. The sheath is in the form of an elongate gutter with much-incurved edges, and the bristles lie along the groove. When about to obtain food, the bristles are pushed beyond the tip of the sheath into the plant tissues, and, being placed closely together, act as a tube to draw up the plant-juices on which most of the insects feed. It is doubtful whether the sheath does any piercing work. It is this type of mouth which makes the pests in this order so hard to combat, as it is useless to apply poison sprays to the plants—one must directly destroy the insect itself. By running a pin along the groove in the sheath one can lift out the bristles. In the cicada and many bugs, only three bristles can be seen; this may be due to the fusion of two

of the bristles—or, at least, they may be closely adpressed.

There are two sub-orders—(1) **Homoptera**, (2) **Heteroptera.**

SUB-ORDER HOMOPTERA.

(Cicadas, Scales, Aphides, Froghoppers, etc.)

Characters: (a) The wings, when at rest, are held in a roof-like manner over the body. (b) The whole front wing is of the same texture. (c) In the scale insects the front wings only are present in the male; the females are wingless.

Fig1. Nymph of Cicada
a Wing pad

Fig2. Digging Leg of Larva

Fig3 Part of twig with pieces of bark cut by female

Fig4. Adult
a. Flap of drum.

Fig5. Head
a. Proboscis

Fig6. Sheath of Proboscis

Fig7. Stylets of Proboscis

Fig8 Section of Probascis
a. Stylets
b Sheath.

Fig9. Head of Cicada
a. Eye. b. Ocelli

The Cicada

Fig 10. Membracid

Fig11 Froghopper.

FAMILY CICADIDÆ.

(Cicadas.) (Plate 48, Fig. 4.)

These "squeakers" or "locusts" of children are really cicadas. Historically the cicada is one of the most ancient of insects mentioned. A cicada on the string of a cythera was the symbol of music for the Greeks. We read also of these insects being put in cages and used as a source of entertainment by the Greeks. This seems rather amusing to us, and a cage full of "double-drummers" would be more likely to drive guests home than serve to entertain them. Only the male insects are capable of producing the "song."

Cicadas are found from October to February. They vary in size from one to several inches across the wings. The head is somewhat triangular in shape; the compound eyes are large and prominent; between these eyes are three **ocelli,** or single eyes, which look like jewels. (Plate 48, Fig. 9 b.) The antennæ are very short and inconspicuous. The front part of the head is prolonged into a sheath, which encloses the bristle-like mouth parts. (Plate 48, Fig. 5 a and Figs. 6 and 7.) This sheath is jointed, and is in the form of a much-curved trough or groove, opening in front. The bristles lie in the groove. The wings are membranous, and are supported by a few strong veins; the hind pair is smaller than the fore wings.

Inside the body, just at the junction of thorax and abdomen, towards the upper surface, the sound-producing apparatus is situated. But the so-called "drums," or flaps or dampers (Plate 48, Fig. 4 a), are on the under side, and they protect the sound-chambers below, which are circular. Across each chamber is stretched a beautiful opalescent membrane; this seems to correspond with the drum parchment of an ordinary drum. But this membrane does not produce the sound—it seems rather to be a kind of sounding-board. Also when the membrane is pierced by a pin the sound of the cicada is not silenced. Powerful muscles work certain internal plates, causing them to vibrate, and by means of these the sound is produced.

The eggs are laid in little slits made by the sharp ovipositor of the mother-cicada, and so numerous are these cuts that the twig is often rough with the little "tags" of bark left by the slit. (Plate 48, Fig. 3.) The eggs hatch in from six to eight weeks. The larva is a queer-looking object with large head and strong front legs. On leaving the egg it drops or crawls down to the ground, into which it cuts its way to a depth of one or two feet, and there it lives, feeding on the roots of plants. A distinct tunnel is made in the soil.

The period passed in the larval stage varies with the genus, but it may be from three to 17 years. —the latter period was recorded in America. We have noticed, on the coastal districts of New South Wales, the appearance of cicadas in great number at three or four year periods; hence it has

been suggested that the species thus noted occupies about that time in the larval stage.

The larva is suited for this underground life by the smooth, rounded form, and by the presence of a front pair of cutting and digging legs—strong and broad, with pincer-like claws. (Plate 48, Figs. 1 and 2.) One can distinguish the older larva or "nymph" by the presence of wing-pads. (Plate 48, Fig. 1 a.) An underground home of a cicada was brought to us intact by a friend, who dug it out of her garden. It consisted of a branched tunnel about $1\frac{1}{2}$ ins. in diameter; the walls were firm and hard, so that there did not appear to be any danger of their collapsing. Sometimes the nymph constructs a chimney three or four inches above the ground surface when about to emerge. As a rule, it emerges at night or just about dusk, and crawls on a fence or tree. Here it waits for some time, till the emergence takes place. Children sometimes bring the nymph into the house at evening and watch the adult come from the shell. We observed the emergence of a large "double-drummer" one afternoon, and the sunlight reflected by the soft wings made a most exquisite sight—a play of opalescent colours.

Not much damage is done by cicadas in the process of sucking the juices of plants; but the egg-laying process by the females is sometimes a nuisance in orchards, where the young stems have the bark punctured in hundreds of places. (Plate 48, Fig. 3.) Also these slits make a refuge for other insect pests.

Many popular names are given to the cicadas—"green monday," "yellow monday," "double drummers," "millers," etc.

Some of the commoner species are of genus *Cyclochila*; *C. australiasiae* is the "green monday."

The "double-drummer" is *Thopha saccata*, with bag-like drums at the side of the body.

The "floury baker" or "miller" is smaller, and is a great prize to children, being more uncommon than the "yellow and green mondays."

Small cicadas are very numerous in the western districts of New South Wales.

During the summer of 1919, the number of cicadas was abnormal in their abundance; many residents of Killara and other suburbs had their nights' rest disturbed by the song of these insects, which was continued all through the bright moonlight nights.

FAMILY CERCOPIDÆ.

(Froghoppers.) (Plate 48, Fig. 11)

These are small insects with roof-like bodies and rounded heads. The popular name of "froghoppers" has been given because of their leaping habits. They have the hemipterous piercing and sucking mouth.

The metamorphosis is incomplete. The eggs are laid on the bark of young gum-trees, and when the young come forth they may be seen clustering together. They secrete a sweet fluid called honeydew, and so certain species of ants are on very friendly terms with them, running over them and standing beside them partaking of the sweets, while they thus protect them from other enemies.

The larvæ are usually cream, with brown, black, or red markings, and they hop when touched. The larger larvæ, or nymphs, show wing-pads. Ants are found on both larvæ and adults. The species we have observed attending these are the gravel ant (*Iridiomyrmex rufoniger*), the golden-bodied ant (*Polyrhachis ammon*), and several species of *Camponotus* (sugar ant).

One of the commonest species of froghoppers on gums (Eucalyptus) is the genus *Eurymela*. (Plate 48, Fig. 11.) Certain species secrete such quantities of juice that it forms a frothy mass or spittle, in which several froghoppers live; they are called "spittle insects."

FAMILY APHIDES.

These delicate little insects are found on tips of rose bushes, peach and apple trees, and on the young leaves of many of our garden plants. They have a piercing and sucking mouth, and the body is pear-shaped, with a rounded head with a pair of long, jointed antennæ. The legs are very long—like "stilts." Some forms are winged, but the majority are wingless. Their life history varies with different species. On the fifth segment of the abdomen is a pair of tiny tubes called **siphons**, which stand nearly erect from the body. (Plate 49, Fig. 1 a.) The siphons are said to exude a waxy secretion which it smears on the heads of the enemies who come near enough. From the tip of the abdomen a globule of honey dew can often be seen (Plate 49, Fig. 3 a); this is secreted by the insect and is so abundant that a trail of the sweet, sticky substance is sometimes to be seen showing its track. This honey dew at one time was thought to be secreted and sent out from the siphons. Because of the honey dew, these insects are often attended by ants; and bees and wasps occasionally partake of these sweets. But it is the ants which are the especial friends of aphides and may be seen stroking them and surrounding them as they partake of the honey dew, hence they are often called "ants' cows." This serves as a protection to the aphides. One writer tells of a particular species of aphis which, during the wingless

stage, is wholly dependent on the ants. It lives in the ground, and is carried from the ants' nest to the roots of the plants on which it feeds, and is carried back again to the safety of the nest when feeding-time is over.

The **life history** of these interesting insects is most remarkable, and in some species at least is not properly understood.

Life History of the Common Aphis.

Commencing from the eggs, which are laid in the autumn, numerous wingless virgin females are produced. These in turn produce (within a few days), not eggs, but wingless young. This producing of young without direct fertilisation is termed "*parthenogenesis.*" These daughter aphides again in a few days produce young, and so on; so that one can see why these insects are such plagues, for they are so numerous.

Usually later, true males and females are hatched. These are often winged, but may be wingless. We have noted winged forms on tips of rose shoots in July and August and during very cold weather on the coast. The true females deposit eggs, which remain in crevices over the winter. From these eggs the virgin females hatch. Some species of aphides hibernate during the winter, hiding in crevices in stems and on roots. Orchardists have found that treating the soil around the tree with kerosene emulsion or with tobacco solution gives good result. Spraying leaves and branches with these solutions is also good.

The **woolly aphis** excretes a white, woolly substance, with which it conceals its body. The

name "American blight" or simply "blight" is often applied to this form. This insect attacks the roots and stems of apple-trees, causing irregular, gnarled growths, which are often much larger than the stems themselves.

Vegetables such as cauliflower, turnip, radish, and cabbage are frequently attacked by aphides. The genus *Phylloxera*, which is such a serious pest on grape vines, is an aphis with a complicated life history.

Enemies of Aphides.

The lady-bird beetles (*Coccinellidae*) are one of of the best enemies of this pest. Both larvæ and adults attack them, and are so voracious that, if numerous, will rid the trees of them.

The larvæ of the lace-wing insect are a very effective means of getting rid of aphides. The long, trunk-like mouth can impale an aphis with great ease, and the amusing habit of throwing the skins on their backs is well worth watching.

The larvæ of certain species of hover fly are also devourers of these destructive pests.

The young (particularly) of the praying mantis also feed on them.

Small chalcid wasps parasitise aphides.

We bred out a small black wasp from the dried skin of an aphis which had been used by the wasp as a cocoon, when the wasp maggot pupated. We had noted a curious-looking swollen aphis of a fawn colour, and placed several in a small box and awaited results. Tiny black parasitic wasps emerged (chalcids).

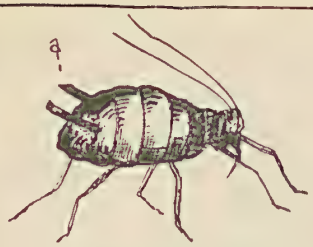


Fig1. Wingless Aphis
a. Siphon

Fig2 Winged Aphis

Fig3. Ant Caressing Aphis
a Drop of Honey-dew.

Aphides.

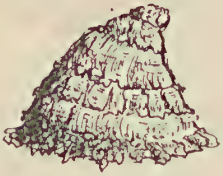


Fig4. Lerp-Scale

Fig5 Eggs & Egg shells

Fig6. Larva

Fig7. Nymph

Fig8. Adult

Lerp Insects

APHIDES AND LERPS.

LERP INSECTS.

FAMILY PSYLLIDÆ.

Lerp insects are sometimes called "jumping plant-lice." The term "psyllidæ" comes from *psylla*, a flea, from the jumping habits of these insects. The adults strongly resemble miniature cicadas, and vary in size from a sixth to a quarter of an inch in length. (Plate 49, Fig. 8.) They can be seen better with a lens. These are well worth looking at, for they are dainty little creatures like "fairy cicadas." They live by sucking the juices of plants, and, if present in great numbers, may become a pest.

The eggs are deposited on leaves, and stand erect or slightly inclined (Plate 49, Fig. 5), for they are fixed firmly on to the leaf. The larvæ (Plate 49, Fig. 6) appear and are similar in form to the adults, but are smaller and have no wing-pads. Later, as development goes on, wing-pads appear. (Plate 49, Fig. 7.) The adult is winged. (Plate 49, Fig. 8.)

In some species the larvæ cover themselves with a white, sugary scale, which is formed from a fluid secreted by the insect. This fluid hardens to form a brittle scale (Plate 49, Fig. 4): seen with a lens this scale is very beautiful. Some are said to secrete a fleecy exudation under which they live; while others make galls—some of a clear red colour—and when these galls open at the top and are

seen with the lens, with a few of the dainty, pale green adults, it is a very beautiful sight.

The life history of the sugar-scale lerp can be nicely seen by collecting lerp scale insects of all sizes, from the tiny baby scales to the larger ones with wing-pads. By keeping some of the larger scales in a box, one may see the adult lerps a little later. The eggs are in clusters or in rows, often along the midrib of gum-leaves; they are of a brown colour, and it is hard to distinguish them. (Plate 49, Fig. 5.) The lerp scale, when viewed with a lens, is very beautiful, like bands of ribbon with an irregular edge or fringe. (Plate 49, Fig. 4.)

TREEHOPPERS.

FAMILY MEMBRACIDÆ.

These are small insects which Comstock calls "Nature's jokes." The first segment of the thorax is bent over the body and produced to form projections or spines, so as to give the insects most strange and weird forms from the face view. (Plate 48, Fig. 10.) They are similar in habit of feeding to the other insects of this group. They are never sufficiently numerous to be pests.

LANTERN FLIES.

FAMILY FULGORIDÆ.

(Plate 51, Figs. 9, 10, 11, 12.)

The name "lantern fly" was given to this group owing to the fact that some of the larger insects were formerly thought to be luminous. Recent writers think this is not so. In New South Wales our species are mostly small insects, with roof-like wings frequently mottled and marked with neutral tints, which make them resemble moths.

One of the commonest species is the pale green moth-like fulgorid, which hops away with a great leap as soon as one touches it. The larva is pale green; it feeds on the delicate parts of plants. Its name is *Siphanta acuta.*

Another species, whose larvæ may be a pest on the wistaria vine, is a mottled brown colour. The larva is pale green, and secretes cottony threads and has a fan-like tail of white threads from the tip of the abdomen. The species is *Scolypopa australis.* (Plate 51, Fig. 12.)

At Bowral we noted thousands of these hoppers on a grape vine. The eggs are laid on plants.

The beautiful red lantern fly or fulgorid called *Achilus flammeus* is often seen around Sydney. We bred out a long-nosed fulgorid (Plate 51, Figs. 9, 10 and 11) from a mass of "spittle" or froth which is secreted by the larvæ, and several live in this white, frothy mass. We got three stages of the insects. The older nymph and adult are figured. (Plate 51, Fig. 11.)

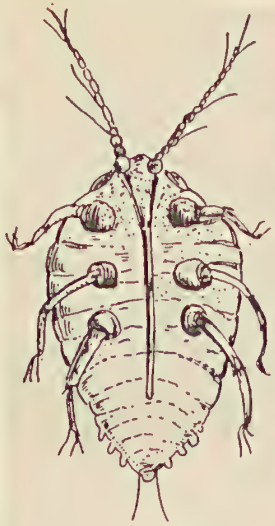


Fig 1. Larva

Fig 2. Female

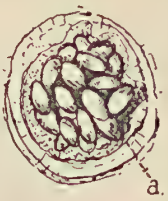


Fig 3. Scale with Eggs
a - Eggs

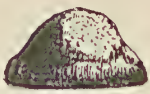


Fig 4. Scale in position

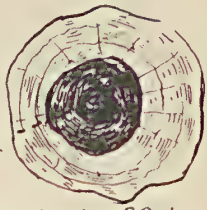


Fig 5. Underside of Scale
a. Pellicle

The Lecanium Scale on Grass Tree

Fig 6 Male Orange scale (After Comstock)

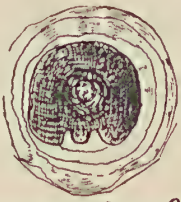


Fig 7. Female Orange Scale

Fig 8. Mealy Bug

Fig 9. Mussel scale.

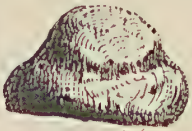


Fig 10. Indian Wax Scale.

Fig 11. Cottony Scale
a Larva.

SCALE INSECTS AND MEALY BUGS.

SCALE INSECTS.

FAMILY COCCIDÆ.

(Scale Insects, Mealy Bugs, Gall Insects, etc.)

These insects are small and often microscopic. Great variety in mode of life is displayed; some form waxy or resinous scales, under which they live.

Scale Insects (Plate 50) may be easily transported from one country to another by introduced plants, which may have eggs or minute creatures present. In this group are some of our most serious pests.

The Red Orange Scale (*Aspidiotus auranti*) (Plate 50, Figs. 6 and 7). When a boy is draining the juice from a freckled orange he little thinks that he may be getting a plentiful supply of tiny scale insects from the skin. This scale is circular in form, of a reddish-brown colour, dark in the centre and lighter at the edges. The central part of the "roof" is formed of the cast-off skins of the insects, and is called the *pellicle*. (Plate 50, Fig. 5.) The larva emerges from under the parent scale. The young female is wingless, and is oval-shaped, with six legs and two antennæ. Almost immediately, she chooses a spot and inserts her sucking mouth into the plant tissues and begins to feed; and shortly the scale is formed from secretions from the body, and in a day or two the

insect is entirely concealed. She never leaves the spot. As she develops, she loses legs and antennæ as the skins are shed, and a very long sucking tube develops: the anal end of the body is usually lobed. (Plate 50, Fig. 7.) The eggs are numerous, within the body, and from 100 to 200 living young are deposited. The male insect commences life as a six-legged larva similar to the female; it forms a scale and is said to pupate under it. The adult male is winged, but with fore wings only; there is a pair of hooks, which occur behind the fore wings. (Plate 50, Fig. 6.)

Types of Scales.

The Palm Scale, of genus *Lecanium*, is a rounded, bluish-brown scale found on palms, in orchards, and on garden plants. One species is called the "olive scale," and it has fluted margins. We found a species of *Lecanium* on the leaves of the grass tree (*Xanthorrhœa*). (Plate 50, Figs. 4 and 5.) On examining various scales, we found eggs under many of the larger scales. (Plate 50, Fig. 3.) The larvæ were in all stages of development. Under another scale we found a female (Plate 50, Fig. 2), while from beneath yet another one we found the pupa and larva of what appeared to be a parasitic wasp. A young larva is shown on Plate 50, Fig. 1.

Another type of scale pests is *Mytilaspis*, the mussel scale. (Plate 50, Fig. 9.) In the bush there is a soft, creamy scale, the individuals of which cluster so closely that they completely surround twigs of gum-trees. It has an opening at the apex, and its name is *Eriococcus*.

The species *Aspidiotus perniciosus* is closely allied to the red orange scale; it is a serious pest in orchards, appearing as tiny grey specks on the bark, and at times on the fruit of peach, apricot, nectarine, plum, pear, apple, and quince.

The Indian wax scale (*Ceroplastes ceriferus*) is another pest, which has special favourites among plants such as *Pittosporum, Duranta, Bursaria,* etc.

A mealy bug resembling a scale insect is "the cottony cushion scale" (*Icerya purchasi*). This is a large scale, with white cottony secretion, with radiating ribs. (Plate 50, Fig. 11.) It is a pest on citrus trees, though it was originally found on wattle trees. The young larva has long white threads from the end of the body. *Icerya* is really a mealy bug scale.

FAMILY COCCIDÆ.

(The Mealy Bugs.)

This is a group of insects similar to scale insects which, instead of forming a true scale, produce a mealy secretion which covers their body. One species secretes threads, and these are sometimes worked up to form a scale-like covering. *ex.*: "Fluted cottony scale" (*Icerya purchasi*). (Plate 50, Fig. 11.)

The larvæ of the females of many mealy bugs are usually rather ugly "grubs," with the segments of the body very similar and with very short legs; some species look like wood lice. However, the body is of a red or cream colour, sometimes flecked with black on the edges. One species has a thick, swollen form like a little pig. *Monophlebus* is the common type of mealy bug. (Plate 50, Fig. 8.) The males are winged, and the male of one species (*Callipappus*) is a most exquisite little creature. The two wings are like dainty pink shells, and the tip of the abdomen ends in twisted, stiff silken bristles.

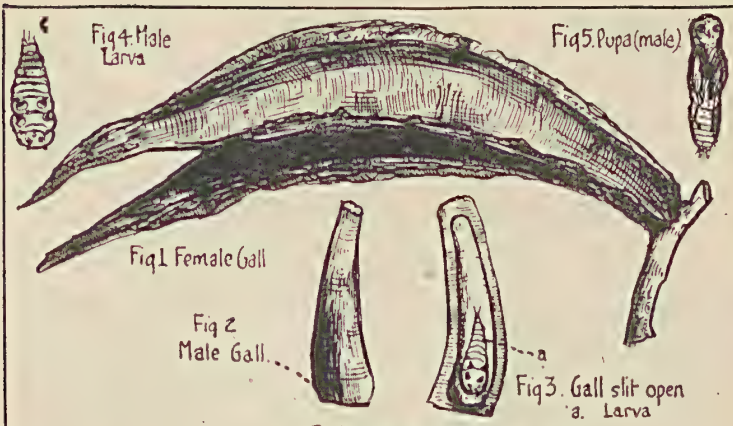
GALL-MAKING COCCIDS.

These include some of our "curiosities" in insect life, for we have some of the largest galls in the world. The gall is thought to be formed by the stimulation to growth given by the feeding of the gall insects on the tissues of the plant. At any rate, the plant-tissues grow abnormally in this spot and envelop the little coccid. Later, the soft plant tissues may become woody and very thick, with just a relatively small chamber for the insect in the centre. (Plate 51, Fig. 4.) The female passes practically the whole of her existence within the gall; the latter is more or less rounded. There is always an opening of small size at the apex, through which impregnation of female takes place.

The male passes the first part of his existence in a usually much smaller gall (Plate 51, Fig. 2), and it is, in most cases, very different in shape from that of the female. It may be situated close to or at a distance from the female gall.

The genus *Apiomorpha* includes some of our largest galls. Some are top-shaped, others pear-shaped; while the large rectangular gall (Plate 51, Fig. 1), with curious flat tails, may be three inches long. It is called *Apiomorpha duplex*.

We cut open a green specimen (one of the pear-shaped galls), and saw within the creamy, pear-shaped wingless gall, with head down and body prolonged to a point. (Plate 51, Figs. 4 and 5.) We examined with a lens; the legs and sucking-mouth parts could be seen. It secretes a powdery material, which forms a soft lining to its home.



Galls of Apiomorpha duplex

Fig 6. Female Gall of an Apiomorpha.

Fig 7. Gall slit open
a. Larva

Fig 8. Larva of Female Gall.

Gall Insects

Fig 9. Home of Spittle Fulgorid.

Fig 10. Spittle fulgorid

Fig 11 Nymph of same

Fig 12. Nymph of Brown Fulgorid.

GALLS AND FULGORIDS.

ORDER HEMIPTERA.

SUB-ORDER HETEROPTERA.

(Bugs.)

The metamorphosis is incomplete, and the younger larvæ usually differ markedly from the adults' tints; in one species where the adult is green the larvæ resemble autumn leaves of beautiful orange red.

These insects vary in habits and in size. They have the piercing and sucking mouth (Plate 52, Fig. 8), and live, in most cases, on plant juices, though some are carnivorous; some are aquatic in habit. The metamorphosis is incomplete.

The **wing formation** is important, and serves to distinguish this group from the other sub-order (Homoptera). The inner half of the fore wing is opaque and horny, while the outer portion is membranous and semi-transparent. (Plate 52, Figs. 7 and 10.) The hind wings are membranous. (Plate 52, Fig. 7 b.)

The antennæ are usually prominent, but may be wholly concealed beneath the head.

Bugs are found more frequently on the foliage of plants, but also on bark of trees, under stones and logs; hence most bugs are pests, though some of the carnivorous types feed on leaf-eating caterpillars.

A noticeable feature of many of these insects is the enlargement of the part of the third seg-

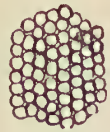


Fig 1. Egg cluster

Fig 2. Egg shell
a. Lid shell

Fig 3. Egg
a. Frame

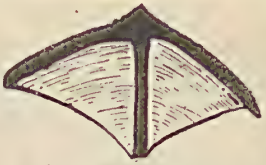


Fig 4. Frame (magnified).

Fig 5. Nymph
a. Wing pad.

Fig 6 Larva

Fig 7. Shield Bug
a. Cover wing
b. Flying wing

Fig 8. Proboscis
a. Sheath.
b. Stylets.

Fig 9. Adult bug
a. Scutellum

Fig 10 Cover wing
a. Membraneous Area.
b. Horny Area

PLANT BUGS.

ment of the thorax called the *scutellum*, and in some cases this so enlarges as to completely cover the wings (Plate 52, Fig. 7.) Such types are called popularly "shield bugs," and belong to the Pentatomidæ; some pentatomids have a scutellum which is simply enlarged and not covering the wings.

FAMILY PENTATOMIDÆ.

Many are noted for the beautiful metallic colours of the scutellum. The colours are frequently very gay; *ex.*: bright red, green and blue, with black patches, etc. They are plant-eaters, and may be pests. The common "green bug" (*Cuspicona*) (Plate 52, Fig. 9) of the vegetable and flower garden is a pest. It has a large scutellum, but it does not cover the wings; it is about half-way down the abdomen. The sucking mouth of stylets and sheath described before is present. The stylets are very slender and grooved. (Plate 52, Fig. 8.)

The eggs are laid in clusters on leaves of vegetables. We found a group of these pearly eggs (Plate 52, Fig. 1) on the under side of a bean leaf, and, on observing them with a lens, saw they were slightly depressed at the top. The eggs are opened by the baby bugs by means of a little triangular framework. (Plate 52, Figs. 3 and 4.) This can be seen in the egg shell by means of a lens. When the baby bug first emerges it is very like a tiny black spider. (Plate 52, Fig. 6.) Fresh leaves were put in each day, and the life history was

followed. Later on the black baby-bug had patches of red and white spots, in two rows. After each moult slight changes occurred in colour. The black gave place to green, and the spots were less marked and bright. At last wing-pads appeared (Plate 52, Fig. 5), the head became more pointed, and the spots disappeared. When the adult stage was reached it was entirely green, and it is hard for young students to believe that the well-marked larvæ could develop into green bugs. (Plate 52, Fig. 9.)

Shield bugs are numerous in our scrub country of the Northern Rivers of New South Wales. On the beach, at high-water mark, at Bellinger Heads, we saw thousands of them. They had evidently been driven seawards by the high winds and fierce heat from the bush fires which were raging on the coast. These bugs have two tiny glands on the under surface of the body, from which the well-known obnoxious-smelling fluid is excreted. One of the shield bugs has proved useful in preying on the larvæ of the grape-vine moth (*Phalaenoides*).

BED BUGS.

FAMILY CIMICIDÆ.

These insects are found in human habitations. They have a flat, circular body, and are without wings. They can live without food for months; they love the dark, hiding in crevices,

The eggs are tiny oval bodies with a rim at the upper end. They are in clusters of from six to fifty; they hatch in seven or eight days. At first the young bug is transparent, with a very narrow body. It later becomes darker, and develops after a series of moults to the adult wingless form. The time taken in development varies with the weather. Warm weather and abundance of food results in rapid development. Under ordinary conditions about seven weeks elapse before the adult stage is reached. They are very tenacious of life. Cockroaches, ants, and even some species of bugs prey on them.

ASSASSIN BUGS.

FAMILY REDUVIIDÆ.

These are carnivorous, and hunt their prey, and a marked difference is noted. They are much more active, with strong running legs, and with a stout, shorter, slightly curved beak, suitable for piercing the body of a victim. The tip of the beak rests in a groove between the fore legs. Some of the commonest are of red or orange colour, with black markings. Their bodies are long and narrow. They are captured on foliage of trees, on bark, etc.

CHINCH BUGS.

FAMILY LYGÆIDÆ.

In this family is the famous "Rutherglen bug," one of the most destructive pests in Australia. It is about a sixth of an inch long, and has grey wings spotted with black, and may be mistaken for a small fly. It attacks all kinds of cereals and many fruits. It is thought that these bugs hibernate during winter in grasses and weeds. The eggs are laid on grass, and after two or three weeks the young come forth. At first they are pale green and wingless. After the first moult it becomes bright red; later it changes to a dull red. When full-grown it is grey or brown in colour. Development takes several weeks.

This bug does serious damage to wheat crops at times. On fruit—particularly peaches—it causes black, pit-like spots, from which a globule of gum-like substance exudes.

Dilute kerosene oil and soap contact sprays are of some use, except on hot days, when the insects fly off readily. Care must be taken that the sprays are not strong enough to spot or taint ripening fruit. Shaking the branches over a shallow dish of kerosene and water, in the early morning, when these bugs seem inactive, has proved one of the most effective measures in coping with them. Grass or weeds in orchards should be turned in before spring to destroy eggs which may be thereon.

Fig 1 Water-stick Bug a. Air Tube.

Fig 3 Water Skater Bug.

Fig 2. Water Scorpion a. Air Tube.

Fig 4 Water Boatman (Corixid)

Fig 5. Back swimmer. (Notonectid).

WATER BUGS.

WATER BUGS.

I. WATER-STRIDERS OR WATER-SKATERS. FAMILY HYDROMETRIDÆ.

(Plate 53, Fig. 3.)

It is very interesting to watch these water-skaters skimming over the surface of the water. They have usually exceedingly long, slender legs and a rather lens-shaped body. They are difficult to catch, for they have keen sight and are so active that they are almost at the other side of a pool before one can get near them. We saw dozens of these merry skaters at the bottom of a gully at Heathcote, after heavy rains. The stream was rushing along, but in little sheltered turns in the bank many of these water-skaters had collected. They feed on small insects, etc. The eggs are laid in jelly-like globules attached to water-plants. In colder climates they winter in the water and on banks, and do not come to the surface till spring.

Hydrometra and *Gerris* are the common species.

II. BACK-SWIMMERS.

FAMILY NOTONECTIDÆ.

(Plate 53, Fig. 5.)

These are interesting little water bugs which remind one of rowing-boats, for they swim on their backs or they may float with the hind legs extended and now and then moving them gently like a pair of oars; these legs are much longer than the other pairs. (Plate 53, Fig. 5.) The back of the

body is shaped somewhat like the keel of a boat, and this enables it to cut through the water. These insects have to carry a supply of air down with them, and they do so under their wing-covers; they are lighter than the water, and have to hold on to objects or swim in order to remain under the water. They are very active insects, for they are predaceous and are armed with the stout, short piercing beak, which can hurt one's finger in handling them. They may fly from pond to pond; but they can be kept in glass jars, with plenty of water weeds, for months, without needing any special food, though they enjoy mosquito larvæ. The prothorax slightly overlaps the head, the hind legs are the longest, and the back is keeled—these points serve to distinguish them from the next group, water boatmen. The common genus is *Enithares.*

WATER BOATMEN. FAMILY CORIXIDÆ.

(Plate 53, Fig. 4.)

The dorsal surface of these bugs is flat, and they swim on the ventral side; this serves to distinguish them from the back-swimmers. The front legs are longest, and are clothed with fringes of hairs (Plate 53, Fig. 4.) The water boatmen can obtain their air by renewal with the air in the water, and the whole body is covered with a film of air. One can see these boatmen, kept for a time in jars of water with water weeds, holding on to the plants and gently moving the hind legs to promote circu-

lation in order to renew the air. The film of air round the bug makes it glisten like silver-plate.

The eggs are laid on water-plants, and in America, in certain parts, these bugs are so numerous as to be collected and sent to England as bird food. The common genus is *Corixa*.

WATER SCORPIONS. FAMILY NÈPIDÆ.

(Plate 53.)

One species, *Nepa* (Plate 53, Fig. 2), has a broad, flattened head and body. At the end of the latter are two long, slender bristles, grooved on the inner side; or, putting the bristles together, a tube is formed, and these insects can lie on the mud of shallow pools and project the tube to obtain air in order to breathe. The body of this insect somewhat resembles a scorpion.

The front legs are fitted for seizing and holding prey, and the beak is fitted for piercing the body of insects, for it is short and strong and curved under the thorax. Nearly all the carnivorous types have this relatively short strong proboscis.

In this group is a curious insect, *Ranatra* (Plate 53, Fig. 1), which resembles a mantis or a phasmid. It has a long, stick-like body and long, slender legs. The front pair of legs is shorter than the others, and is fitted for seizing prey; they are very strong. The colour of these insects blends with their surroundings, and they are thus more easily able to get their prey, as they lie in the mud on the bottom of shallow pools.

FISH-KILLERS.

FAMILY BELOSTOMIDÆ.

These are giant bugs, and are the largest hemipterous insects, measuring as much as four inches in length. They have strong flight, and we have captured specimens flying round lamp-posts or electric light in Sydney. The tip of the abdomen ends in a spine. The front seizing legs are very strong, and the beak is the typical short and strong type of predaceous bugs. They are found chiefly in the Northern Rivers districts of New South Wales.

LICE.

ORDER ANOPLURA.

(Sucking Lice.)

The exact position of these creatures in relation to the Hemiptera is doubtful. Some writers put them in a separate order, **Anoplura,** whilst others regard them as a degenerate type of bug. They are small insects, with pear-shaped bodies. The head bears a pair of eyes and a sucking apparatus; they have six legs and are wingless. Most domestic animals, as well as many birds, are infested with a distinct species of this insect. Metamorphosis is incomplete.

These insects should not be confused with the biting lice, Mallophaga, equally common on birds and on mammals. These biting lice are degenerate Neuropterid insects.

ORDER HEMIPTERA

Sub-orders **Homoptera** | **Heteroptera**

Sub-order **Homoptera** includes:—

Families **Cicadidæ** (Cicadas)
Cercopidæ (Froghoppers)
Aphidæ (Aphides)
Psyllidæ (Lerp Insects)
Membracidæ (Treehoppers)
Fulgoridæ (Lantern Flies)
Coccidæ (Scales, Mealy Bugs, and Gall Insects)

Sub-order **Heteroptera** includes:—

Families **Pentatomidæ** (Shield Bugs)
Lygæidæ (Chinch Bugs)
Cimicidæ (Bed Bugs)
Reduviidæ (Assassin Bugs)
Hydrometridæ (Water-striders)
Notonectidæ (Back-swimmers)
Corixidæ (Water Boatmen)
Nepidæ (Water Scorpions)
Belostomidæ (Fish-killers)

ORDER THYSANOPLERA.

(Thrips.)

This order contains almost entirely minute forms of fringed or tasselled-winged insects. The wings are surrounded by minute cilia which form a fringe. Many of the thrips are microscopic; others can be seen as mere lines or flecks, and it is only by means of a microscope or very powerful lens that we can make out anything of their structure. The mouth parts are peculiar, but a pair of sucking jaws can be distinguished. Thrips are found infesting the buds of our roses and carnations in early spring; particularly is this the case in very dry seasons. They also attack the opening blossoms of the apple tree, resulting in some cases in the loss of almost the entire season's crop. Flowers of weeds, grasses, and many of our vegetables, as tomatoes and onions, are not exempt from their attacks.

The **eggs** may be deposited in the bud, leaf, stem or even calyx. These hatch in a few days. The **larva** is a minute form with six legs and a pair of antennæ. A brief nymph stage follows, in which wing-pads are developed, and from this comes the adult. The life history of the common thrips found in our roses occupies about 21 days.

An emulsion of tobacco and soap, or lime and sulphur, has been found useful, but fumigation seems to be the only real effective means of dealing with these minute insects.

In addition to the forms already mentioned, we have in Australia a giant thrip which measures almost half an inch in length. In this species the

structure can be seen with the naked eye. We have captured this insect in numbers among the dead leaves of fallen gum trees. Branches were lifted and shaken into an upturned umbrella, and as a result numbers of the little forms were seen actively moving about.

COLLECTING AND PRESERVING INSECT LIFE.

In order to become acquainted more intimately with the form and structure of insects one must be in possession of specimens, in order to make accurate observations, and to become possessed of such specimens collecting is necessary. Certain material is also necessary to do this work effectively.

We will mention first the butterfly net, which consists of a ring of wire about 12 inches in diameter. On to this ring a bag made of mosquito net is sewn; then the ring is bound with tape or calico. The length of the bag should be at least one and a half times the diameter of the ring—this is to allow the bag to swing across the ring when the insect is captured, and thus prevent its escape.

A neatly-designed folding ring can be purchased, but is rather an expensive item, and is no more effective than a home-made one constructed of a piece of stiff wire such as is seen in fences. The ends of the wire should be twisted around one another for 5 or 6 inches. When the collector goes out he should carry a strong piece of tape or, better still, attach the tape to the ring; then by this means a strong stick, cut in the bush, can be more easily attached than with an ordinary piece of string as the tape does not slip. The net bag is frequently dyed green with ink, but this is not an important detail.

A similar ring to that just described, but with a shallow net, is used for capturing water forms.

A **killing bottle** consists of a jar or bottle with a wide neck, and closed with a cork or glass stopper. Into this bottle is put a mixture of potassium cyanide set in plaster of paris. First a layer of the latter, then cyanide, then another layer, and so on until there are about 2 inches of the mixture in the bottle. Moisture will frequently be found to issue from the surface of this mixture. A small piece of blotting paper placed on the surface will absorb this. Insects placed in this type of bottle die almost immediately.

A second type of killing bottle is one containing a pad of cotton wool saturated with chloroform. This is useful, but loses its strength readily through contact with the air by the removal of the cork.

The cyanide bottle has proved the more useful, and is the one generally used. Insects should be removed from the bottle when dead, although they may be allowed to remain for a few hours without any apparent injury. If permitted to remain in the bottle longer they will possibly become discoloured and their beauty will be spoilt.

After removal the insects in most cases are stretched. For this purpose a stretching board is used. Such a board consists of a piece of soft wood, about $\frac{3}{4}$ in. in thickness and from 4 in. to 6 in. in width. Down the centre a groove is made a little over $\frac{1}{4}$ in. in width. On the surface of the board, and also in the bottom of the groove, a layer of thin cork or cork composition is glued, then over the

whole white paper is pasted. The above just describes an ordinary board, but the collector will have several, with grooves varying in width and depth according to the types of insects to be stretched.

We will take a butterfly to illustrate the method of stretching. A steel pin should be placed through the thorax; then the insect should be placed so that the body fits into the groove. The wings should be arranged so that the front ones are well forward in order to allow room for the hind pair to be displayed. Getting the wings into position is not always easy. Do not touch them with the fingers, as the scales so readily rub off. A pair of small hat pins, in the absence of proper needles, will be found most useful. Place one of these along the firm outer edge of the front wing, and gently bring the wing forward into position. Strips of paper, about ½ in. wide and with a rough surface, should be in readiness. Secure the upper end of a strip with a pin to the board, then run the finger down on this paper, holding it firmly and fastening the lower end, of course taking care that the hind wing is in position. In this way both wings are held. Do the same with the wings on the opposite side. Then, to aid further, place two strips of paper across the insect. Leave the insect in this position on the stretching board until it is perfectly rigid. The pin is as a rule placed through the centre of the thorax, except in the case of beetles and small insects. In the former it will soon be found out that the pressure required to put the pin through the hard prothorax will probably smash your insect. A vulnerable spot is found a

little to the right of the centre of the wing covers. In the case of small insects, such as some of the flies, wasps and ants, a piece of thin white cardboard is cut about 1 in. by ½ in. A pin is put through one end, the other end is smeared with gum or thin starch, and then the small insects are arranged by means of forceps and adhere readily to the gummed surface.

Entomological pins of various sizes can be bought, but as these are rather expensive dressmakers' steel pins answer the purpose for the ordinary collector in the early stages of his work. After the insect is removed from the stretching board it should be set out. For this purpose a setting box is necessary; this consists of a box opening in the centre, each half being similar, one portion fitting closely on to the other when closed. Such box should be made of light wood and about three inches in depth. It should be lined with cork or cork composition; failing to procure either of these substances, linoleum might be used as a substitute. The lining material is glued to the box, and then the whole of the inner surface is covered with white paper. Frequently lines are ruled on the paper to assist in the better arrangement of the insects. Each insect should have a label attached, either to the pin which holds the insect or immediately below it pinned to the box. The label should shew the order, family, genus and species to which the insect belongs; also the popular name, if any, and date and place of collecting.

Instead of a setting box such as we have described, and which will probably be far too expensive for the

young student, we have found that cigar boxes will answer the purpose temporarily, and good work can be done.

The larvæ of insects are usually preserved in spirits, or formalin in small tubes or even bottles. Junket tubes can be used for this purpose, although sets of varying sizes can be purchased.

In some instances the soft contents of the bodies of caterpillars are removed so that only the skin remains. This is inflated, then dried in an oven, and finally set out in an ordinary setting box. The cigar boxes already referred to might be utilised to good purpose for setting out the whole life history of one particular insect. Take for instance the vine moth, or emperor gum moth; such life history box would show the eggs, larva (in tubes), pupa and perfect insects. A record of the various happenings might be written on the inside of the lid. Children should be encouraged to work out and set up as many of these life histories as possible.

A few other items might be mentioned for a collector's outfit; among these are a good lens and a pair of forceps. To the naked eye only a part of the wonders of nature is revealed.

On an excursion a few small tins, boxes, bottles and even envelopes might be carried. Last of all we might mention that a bag made of canvas containing several pockets to hold the various articles will be found most valuable. Such a bag should be carried by means of a shoulder-strap, and thus the collector is left with both hands free.

Index

Abdomen, 4.
Abispa, 87.
Acacia gnat, 332.
Acalyptrate muscidae, 353, 368.
Achilus flammens, 390.
Acridiidae, 49.
Acridopeza, 56.
Acrophylla titan, 38.
Adelium, 345.
Aenictus, 155, 157.
Aeschna, 100.
Agarista agricola, 317.
Agaristidae, 316.
Agrotis infusa, 318.
Alastor, 130.
Alula, 327.
Ammophila, 177.
Anaphaeis java-teutonia, 289.
Anax, 68, 70
Andrena, 107.
Andrenidae, 203
Andrenids, 107.
Animal Kingdom, 1.
Anisolabis, 42.
Anisoptera, 67, 70.
Annulata, 1.
Annomma, 155.
Anoplognathus, 235.
Anoplura, 408.
Anostosoma, 56.
Antennae, 1.
Ant Eater, 151.
Antheraea eucalypti, 121, 307.
Anthomyidae, 355, 365.
Anthrophila, 109, 203.
Ant, 101, 149.
Ant lions, 79, 86.
Ants' cows, 151.
Aphaniptera, 373.
Aphidae, 409.
Apanteles, 127.
Aphides, 82, 376, 409.
Apidae, 203, 204.
Apiomorpha, 396.
Apis, 212.
Aptera, 13.
Apoda xylomeli, 310.
Arachnida, 1.
Archimantis, 31.
Argyromoeba, 347.
Arista, 329.
Army worm, 320.
Arthropoda, 1.
Artificial feeding, 166.
Atalophlebia, 78, 100.
Atta, 149.
Asilidae, 330.
Aspidiotus auranti, 392.
Aspidiotus perniciosus, 394.
Assassin bugs, 402.
Aulacophora olivieri, 257.
Austrocordulia, 100.
Austrolestes, 75, 99.

Bacillus, 36.
Back swimmers, 405.
Bassus, 122.
Bean moth, 319.
Bee bread, 215.
Bee fly, 351.
Bees, 101.
Beetles, 228.
Belenois java, 289.
Belostomidae, 408, 409.
Bembex, 107, 180.
Bent wing moth, 323.
Blastophaga, 115.
Blattidae, 21.
Blood vessels, 6.

Blow flies, 361, 363.
Bolboceras, 237.
Bombardier Carab, 246.
Bombycidae, 307.
Bombylidae, 347.
Bombyx mori, 309.
Bombyx nasuta, 309.
Bot flies, 366.
Bouton, 104.
Braconidae, 126.
Braconids, 109.
Breathing, 6.
Brood cells, 215.
Bugong moth, 319.
Bugs, 376, 402.
Bull dog ants, 153.
Buprestidae, 253.
Butterflies, 274.

Cacochroa, 236.
Caddis flies, 65, 79, 93, 96.
Caddis worms, 94, 95.
Caequosa, 300.
Calliphora oceaniae, 364.
Calliphora rufifacies, 364.
Calliphora villosa, 364.
Callipappus, 395.
Callipers, 41.
Callitriche, 96.
Calyptrate muscidae, 353.
Calosoma, 346.
Camponotus, 134, 137, 139, 158, 383.
Camponotides, 158.
Caprification, 115.
Carabidae, 242.
Carabs, 242, 246.
Carpenter bees, 205, 207.
Carpocapsa pomonella, 313.
Case moths, 301.
Castes, 133.
Caterpillar, 9.
Catopsila pythias, 289.
Caudal, 67.
Cecidomyia acaciae-longifoliae, 332.
Cecidomyia destructa, 333.
Cerambycidae, 259.
Ceratitis capitata, 369.
Ceratopogon molestes, 340.
Cerci, 15, 24.
Cercopidae, 383, 409.
Ceroplastes ceriferus, 394.
Chaerocampa celerio, 300.
Chaerocampa scrofa, 300.
Chalcidae, 112.
Chalcids, 109.
Chalcopterus, 245.
Charaxes sempronius, 282.
Chelepteryx collesi, 306.
Cherry tree borer, 315.
Chinch bugs, 403.
Chironomidae, 340.
Chironomus, 340.
Chitin, 2.
Chlamydopsis, 152.
Chrysopidae, 79, 81.
Chrysopa ramburi, 81.
Chrysididae, 129.
Chrysomelidae, 255.
Chrysomelids, 258.
Chrysolophus, 267.
Cicada, 50, 180, 307, 379.
Cicadidae, 379, 409.
Cicindela ypsilon, 247.
Cicindellidae, 247.
Cimicidae, 402.
Cisseis, 354 .
Claspers, 9.
Click beetles, 251.
Clivina, 246.
Clothes moths, 320.
Coccidae, 392, 395, 409.
Coccinella, 269.
Coccinellidae, 269, 386.
Cockroaches, 18, 21.
Cocoon, 10, 27¢
Codlin moth, 118, 315.
Collecting insect life, 412.

Collembola, 15, 16.
Coleoptera, 228.
Commensalism, 115, 159.
Communities, 161.
Corixidae, 406, 409.
Coxa, 4, 21.
Crane flies, 341.
Craspedia coriaria, 352.
Creophilus, 250.
Crop, 7.

Crotan, 26.
Crickets, 18, 49, 57.
Crustacea, 1.
Cryptophaga unipunctata, 315.
Cuckoo flies, 129.
Culex alboannulatus, 338.
Culex vigilax, 338.
Culicidae, 334.
Cup moths, 10, 310.
Curculionidae, 266.
Cursoria, 18, 21.
Curtilla, 58.
Cuspicona, 400.
Cut worms, 318.
Cyanide bottle, 413.
Cybister, 262.
Cyria imperialis, 254.

Dacus tryoni, 370.
Damsel flies, 67, 68, 73.
Danaida archippus, 279.
Danaida petilia, 280.
Danainae, 278.
Danaus, 279.
Darala ocellata, 305.
Day moths, 316.
Delias aganippe, 290.
Delias nigrina, 290.
Demoiselles, 67.
Development of insects, 8.
Dexiidae, 353, 359.
Diamma, 176.
Diaphonia, 236.
Digestion, 7.
Digger scarabs, 237.
Diploptera, 186.
Diplopterids, 186.
Diplosis eucalypti, 333.
Diplosis paralis, 333.
Diptera, 100, 327, 373.
Discolia, 173, 175, 240.
Dolichoderides, 157.
Dolichoderus, 157.
Doratifera vulnerans, 317.
Double drummer, 381.
Dorylides, 155.
Dorylus, 155.
Dragon fly, 9, 64, 67.
Driver ants, 155, 156.
Drones, 217.
Drone fly, 351.
Dytiscidae, 261, 262.

Earwigs, 18, 39, 43, 249.
Eciton, 155.
Echthromorpha, 122.
Ectatomma, 134, 153.
Eggs of insects, 8.
Elateridae, 252.
Elephantodita pinguis, 54, 56.
Elytra, 228.
Emperor gum moth, 9, 307.
Enithares, 406.
Epilachna, 270.
Eriococcus, 393.
Eristalis tenax, 351.
Erynnis sperthias, 295.
Ethon, 254.
Eulepsis, 282.
Eumenidae, 187.
Eumenes, 190.
Euploca, 280.
Eupoecila, 236.
Eurymela, 137, 383.
Evania, 25.
Exeirus, 180.
Extatosoma, 36, 38.
Eyes of insects, 2.

Families, 11.
Femur, 4.
Fiddler beetle, 236.
Fire flies, 251.
Firewood beetle, 260.
Fish killers, 408.
Flea, 374.
Flesh flies, 353.
Flower beetles, 253.
Flying wings, 228.
Forage workers, 158.
Formica, 160.
Formicidae, 133, 153.
Forficulidae, 39.
Fossores, 171.
Frenulum, 297.
Froghoppers, 157, 376.
Fruit flies, 369.
Fulgoridae, 390.
Fulgorid, 83.

Gall gnats, 332.
Gall making coccids, 396.
Gaster, 150.
Gastrophilus, 366.
Genera, 366.
Geometridae, 321.
Gerris, 405.
Gills, 72.
Glenoleon, 86.
Glow worms, 251.
Glossina morsitans, 364.
Glossina palpalis, 332, 365.
Gnats, 340.
Golden ant, 160.
Grasshoppers, 18, 49.
Gravel ant, 157.
Greenheads, 153.
Gryllidae, 57.
Gryllus, 57.
Grub, 9.
Gyrinidae, 261.

Halictus, 107, 203.
Halteres, 327.
Hawk moth, 11, 297.
Head of insect, 2.
Hearing, 53.
Heart, 6.
Helaeus, 245.
Helicopsyche, 93, 94, 99.
Hemerobiidae, 79.
Hemiptera, 376, 398, 409.
Hepialidae, 323.
Hesperidae, 295.
Heterocera, 274, 297.
Heterogyna, 109, 133, 153.
Heteroptera, 376, 377, 398.
Hemigomphus, 100.
Hesthesis, 260.
Hessian fly, 333.
Hive bees, 212.
Homoptera, 377.
Honey bearers, 160.
Honey dew, 151, 384.
Honey jars, 159.
Honey scarabs, 238.
Horse stingers, 67.
House flies, 360.
Hover flies, 350.
Hydrometra, 405.
Hydrometridae, 405, 409.
Hydrophilidae, 261, 264.
Hydropsyche, 99.
Hydroptidae, 99.
Hymen, 101.
Hymenoptera, 101, 171.
Hyperion, 246.
Hyperparasitism, 127.
Hypoderma, 366.
Hypoclinea, 144.
Hypolimnas, 283.

Ialmenus, 159, 287.
Icaria, 193.
Icerya purchasi, 394, 395.
Ichneumon, 101, 109, 122.
Ichneumonidae, 121.
Idarnis, 117.
Inquiline, 204.
Insecta, 1.
Insect classification, 11.
Insect metamorphosis, 8.
Insect, parts of, 1.
Insect senses, 7.
Integument, 13, 228.
Iridiomyrmex, 137, 157, 383.
Isoptera, 44.

Jewel beetles, 253, 281.
Junonia villida, 281.

Katydids, 53.
Killing bottle, 413.

Labidura, 41, 42.
Labium, 3.
Labrum, 3.
Lace wings, 79, 83, 84.
Lady bird beetles, 269.
Lamellae, 232.
Lamellicorns, 232, 239.
Lamprima, 235.
Lantern flies, 390.
Larva, 9, 11.
Leaf cutting bees, 205, 208, 209.
Leaf-eating beetles, 255.
Leaf rollers, 313.
Lecanium, 393.
Leg of insect, 4.
Leis conformis, 269.

Lepidoderma, 175, 239.
Lepidoptera, 65, 274.
Lepisma, 15, 16.
Lerp insects, 388.
Leto stayceyi, 323.
Lestis, 207.
Leucania unipunctata, 320.
Lice, 408.
Ligula, 104.
Limacodes longerans, 312.
Limacodidae, 310.
Liparidae, 305.
Lipura, 16.
Locust, 19, 50.
Locustidae, 49, 53, 58.
Longicorns, 259.
Loopers, 9, 319, 320.
Lucanidae, 232.
Lucilia, 364.
Luciola, 251.
Lycaenidae, 287.
Lygaeidae, 403.

Macrogyra, 99.
Macrotoma, 260.
Maggot, 9, 10.
Malacodermidae, 251.
Mandibles, 3, 103, 230.
Mandibulate, 64.
Mantidae, 27.
Mantids, 18, 19, 20.
March flies, 345.
Mask, 71.
Masaridae, 187.
Mason bees, 107.
Mason wasps, 129.
May flies, 77, 79.
Maxillae, 3, 65, 104.
Mealy bugs, 395.
Megachile, 207.
Melanitis, 284.
Melophorus, 159.
Membracidae, 389. 409.
Mermeleon, 87.
Mermeliontidae, 79, 86.
Mesothorax, 230.
Metamorphosis, 8, 15, 231.
Metathorax, 4.
Metura elongata, 303.
Microgaster, 126.
Micro-hymenoptera, 114, 117.
Midges, 340.
Mimicry, 152.
Mole cricket, 9.
Monomorium, 148, 157.
Monophlebus, 395.
Mosquitoes, 334.
Moths, 9, 274, 297.
Moult, 9.
Mouth parts of insects, 3.
Mud daubers, 103, 105, 171.
Musca domestica, 360.
Muscidae, 353, 355.
Mutilla, 173.
Mutillides, 173.
Myriapoda, 1.
Myrmecia tarsata, 137, 147, 153, 154.
Myrmecophiles, 151, 152.
Myrmicidae, 157.
Mytilaspis, 393.

Native bee, 222.
Nepa, 407.
Nepidae, 407, 409.
Nest workers, 158.
Neuroptera, 64, 79.
Noctuidae, 318.
Node, 133.
Nomads, 155.
Notonatolica, 96.
Notonecta, 99.
Notonectidae, 405.
Notonomus, 246.
Nymph, 11, 51, 72, 381.
Nymphalidae, 278.
Nymphalinae, 278. 281.

Ocelli, 2, 224, 379.
Odonata, 64, 67.
Odynerus, 130, 190.
Occophylla, 161.
Oestridae, 366.
Oestris ovis, 368.
Oggyris, 159.
Onthophagus, 237, 238.
Onychophora, 1.
Ophion, 121.

Opius, 127.
Orders, 11.
Orthodera, 27.
Orthoptera, 18, 63.
Ovipositor, 2.

Palm scale, 293.
Palpi, 104.
Panesthia, 26.
Paper wasp, 194, 198.
Papilio anactus, 292.
Papilio aegeus, 293.
Papilio macleayanus, 294.
Papilio sarpedon, 293.
Papilio Richmondii, 294.
Papilionidae, 292.
Paragryllacris, 56.
Parasitic wasps, 121, 126.
Paropsis, 204.
Parthenogenesis, 385.
Passalidae, 232.
Pellicle, 189.
Pelopaeus, 109, 181, 183.
Pentatomidae, 400.
Perga, 110, 112.
Periplaneta, 22.
Petalura, 68.
Petiolata, 109, 112, 121.
Petiole, 110.
Phalaenoides, 121, 316, 401.
Phasgonuridae, 53.
Phasmidae, 33.
Phasmids, 8, 18, 19.
Phoracantha, 260.
Phosphorescent, 251.
Phyllotocus, 239.
Phylloxera, 386.
Pieridae, 289.
Pimpla, 122.
Pinara despecta, 309.
Pincers, 42.
Plant-eating beetles, 259.
Plectoptera, 64, 77.
Pleistodontes, 115.
Plumose, 329.
Plusia, 122.
Plusia argentifera, 320.
Plusia verticellata, 325.
Plutella cruciferarum, 325.
Podalirius, 207.
Podocanthus, 36, 37.
Polistes, 193, 194.
Pollen basket, 220.
Polyergus, 162.
Polyrachis, 137, 160, 383.
Polyzosteria, 26.
Ponerides, 153.
Pompilidae, 176.
Pompilids, 109.
Praying insects, 27.
Praying mantis, 8.
Precis villida, 281.
Privet hawk moth, 9.
Proboscis, 361.
Prolegs, 9.
Pronotum, 171.
Propodium, 106.
Prosopis, 204.
Protective coloration, 259.
Prothorax, 4.
Protoparce, 299.
Protoparce convolvuli, 299.
Pseudo tube, 105.
Psychidae, 301.
Psychopsis, 82.
Psyllidae, 388.
Pterohelaeus, 245.
Pulex avium, 375.
Pulex irritans, 375.
Pulex serraticeps, 385.
Pulvillus, 4.
Pumpkin beetle, 257.
Pupa, 9, 10, 11.
Pupal skin, 10.
Puparium, 10, 331, 353, 370
Pterogophorus, 111.
Pygidium, 232.
Pyrameis itea, 281.

Ranatra, 407.
Red orange scale, 392.
Reduviidae, 402, 409.
Repletes, 159.
Rhopalocera, 274.
Rhyssa, 122.
Robber flies, 352.
Rose chafers, 236.
Rostrum, 352.

Rove beetles, 152, 249.
Ruby wasps, 129.
Rutherglen bug, 403.
Rutilia, 359.
Saltatoria, 18, 49.
Sand wasps, 176.
Sanguinea, 163.
Sarcophaga, 52, 353.
Sarcophagidae, 353, 358.
Satyrinae, 278, 284.
Saw, 2.
Saw flies, 10, 101.
Scale insects, 376, 392.
Scape, 266.
Scarabs, 232.
Scarabaeidae, 232.
Scitala, 240.
Scoliidae, 172.
Scoliides, 173.
Scoliid fossores, 186.
Scolypopa Australis, 390.
Scutellum, 400.
Selandria, 112.
Sessile, 109.
Sessiliventres, 109.
Setting box, 415.
Shield bugs, 400.
Silk worm, 309.
Silver fish, 13, 15, 16.
Siphanta acuta, 390.
Siphonaptera, 373.
Siphons, 384.
Skip jacks, 252.
Slave-making ants, 162.
Social bees, 205.
Social wasps, 192.
Soldier flies, 344.
Soldier workers, 158.
Solitary bees, 205.
Solitary wasps, 187.
Species, 11.
Sphegidae, 176.
Sphex, 180.
Sphingidae, 297.
Sphinx ligustri, 299.
Spiracles, 4, 13.
Spittle insects, 383.
Sprays, 52, 53.
Spring tails, 13, 15.
Squama, 329.
Stag beetles, 232.
Staphylinidae, 152, 249.
Stigmata, 4.
Stigmodera, 254.
Stick insects, 33.
Stomyx, calcitrans, 364.
Stone flies, 79.
Stratiomyidae, 344.
Stretching board, 413.
Stridulating, 58.
Sub-imago, 78.
Synagris, 107, 191.
Syrphidae, 350.
Syrphus pucillus, 351.
Syrphus viridiceps, 351.

Tabanidae, 345.
Tachina, 353.
Tachinidae, 353.
Tarsus, 4.
Teara, 305.
Tegmina, 18, 35.
Tegula, 101, 177.
Teia, 121.
Telephorus, 251.
Tenebrio, 244.
Tenodera, 31.
Tenebrionidae, 242.
Tenthredinidae, 109.
Terias smilax, 291.
Termitarium, 47.
Termites, 48.
Termitidae, 44.
Thorax, 4.
Thrips, 18.
Thynnides, 173.
Thynnus, 176.
Thysanoptera, 410.
Thysanura, 15.
Tibia, 4.
Tiger beetles, 247.
Tineidae, 324.
Tipulidae, 341.
Tracheae, 6, 72.
Treehopper, 54, 389.
Trichoptera, 65, 93.
Trigona, 222, 225.
Trochanter, 4.

Trypeta musa, 372.
Trypetidae, 369.
Tsiphone abeone, 285.
Tussock moths, 305.

Veins of wings, 4.
Velum, 219, 226.
Venation, 54.
Vespa, 193.
Vespidae, 186, 193.

Wasps, 101.
Water beetles, 261.
Water boatmen, 3.
Water bugs, 405.
Water skaters, 405.
Water scorpions, 407.
Water striders, 405.
Wax, 213.
Weevils, 266.
White ants, 44.
Whirligig beetles, 261.
Wood borers, 323.
Woolly aphis, 385.
Wrigglers, 73, 336.

Xylocopa, 207.
Xanthorrhoea, 207.

Zeuzera eucalypti, 323.
Zygoptera, 67, 68.

Errata.

Page.

16. Read "Sub-order Collembola" instead of "Sub-family Collembola."
175. Read "Lepidoderma" instead of "Lipidoderma."
285. Read "Eggs of Tsiphone abeone are laid" instead of "Eggs are laid."
347. Read "Agrotis" instead of "Agrostis."
23. Plate 4. Read "Cockroach" instead of "Coachroach."

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